ECO

ECONOMIC COOPERATION ORGANIZATION

(ECO)

TRAINING COURSE

National Cartographic Center of IRAN

The National Cartographic Center of Iran with the support of ECO secretariat holds a training course on:

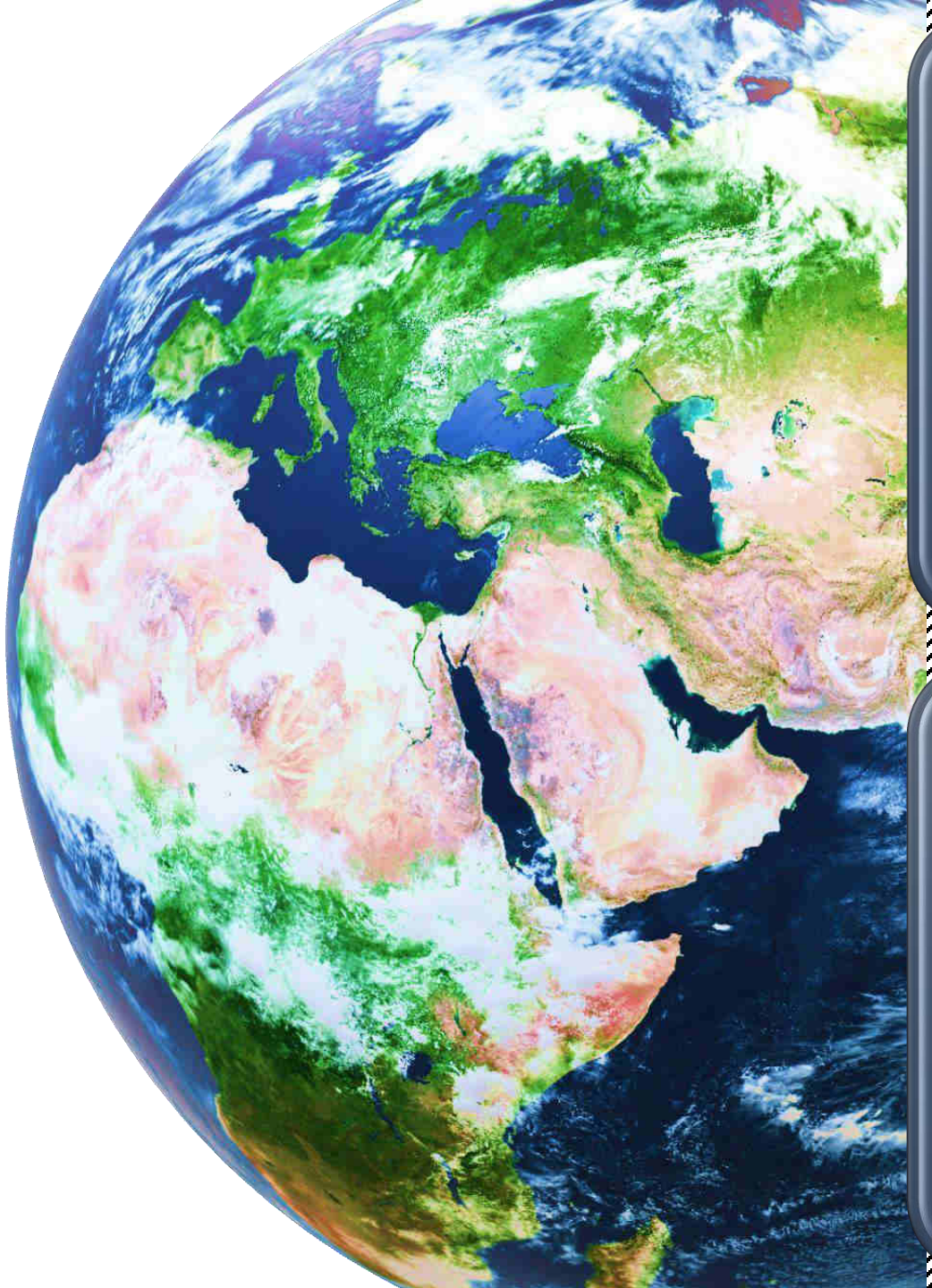
Application of Geospatial Data in Disaster Risk Reduction

16-17 December 2024

National Cartographic Center of IRAN

The role of geospatial information sciences in climate change

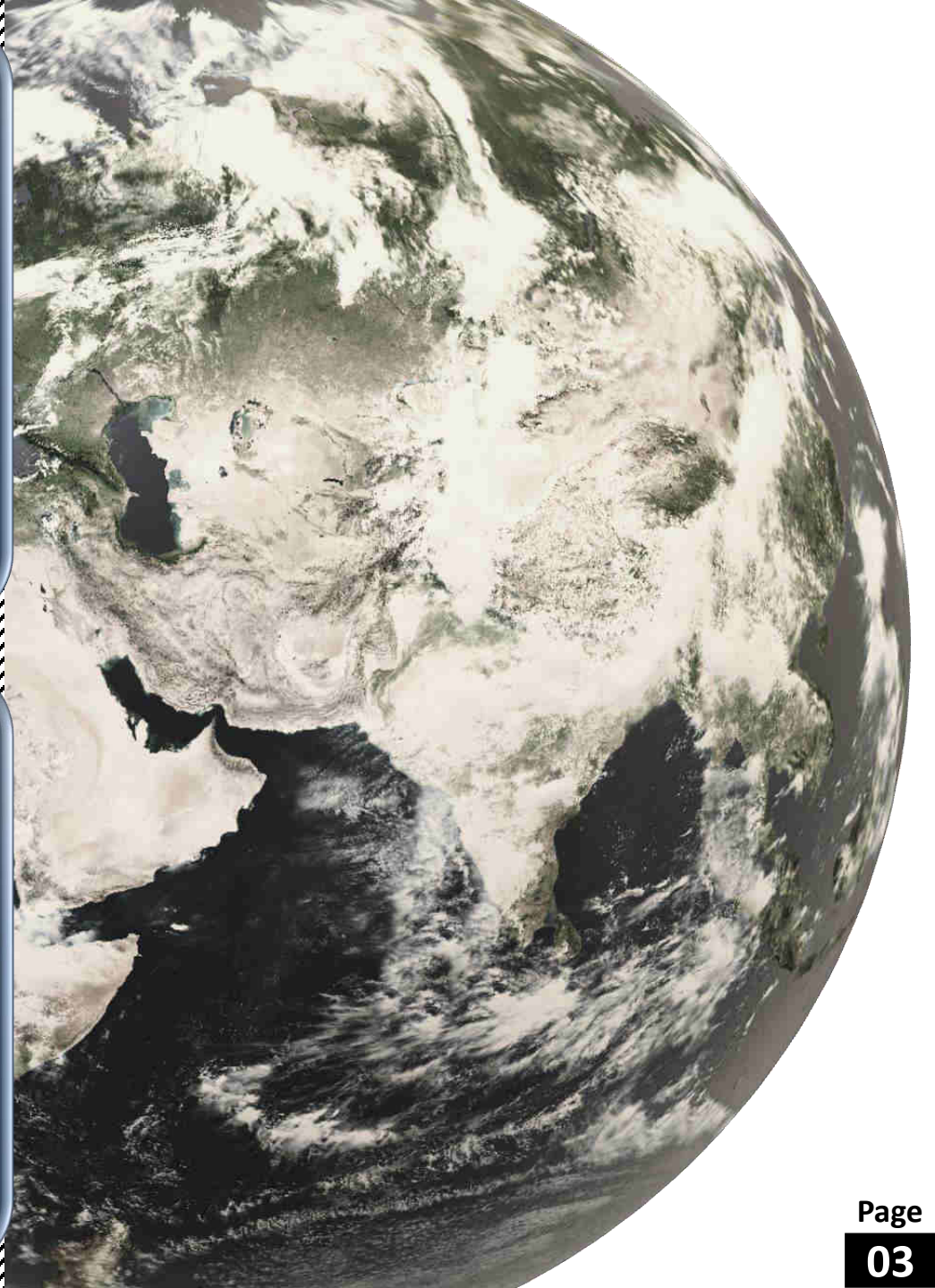
Ramin Papi
Head of the National Geoportal Department
National Cartographic Center of IRAN



What is climate change ?

Causes

Effects



ECO

Causes

National Cartographic Center of IRAN

Greenhouse Gas Emissions

Deforestation

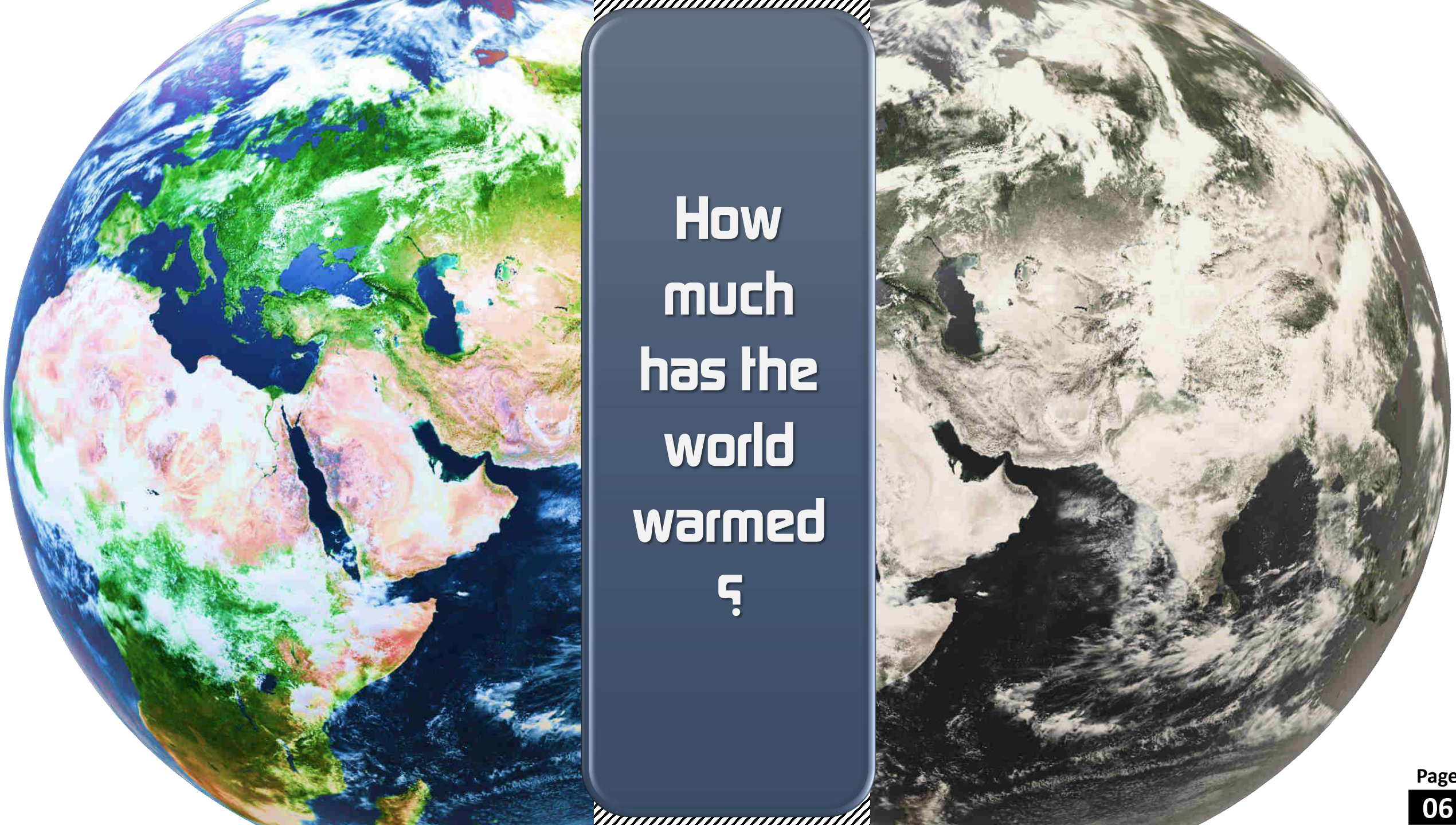
Agricultural Practices

ECO

National Cartographic Center of IRAN

Effects

- Rising Temperatures
- Sea Level Rise
- Ecosystem Disruption
- Melting Ice Caps and Glaciers
- Extreme Weather Events



How much has the world warmed ؟

ECO

Warming

National Cartographic Center of IRAN

Temperature Increase

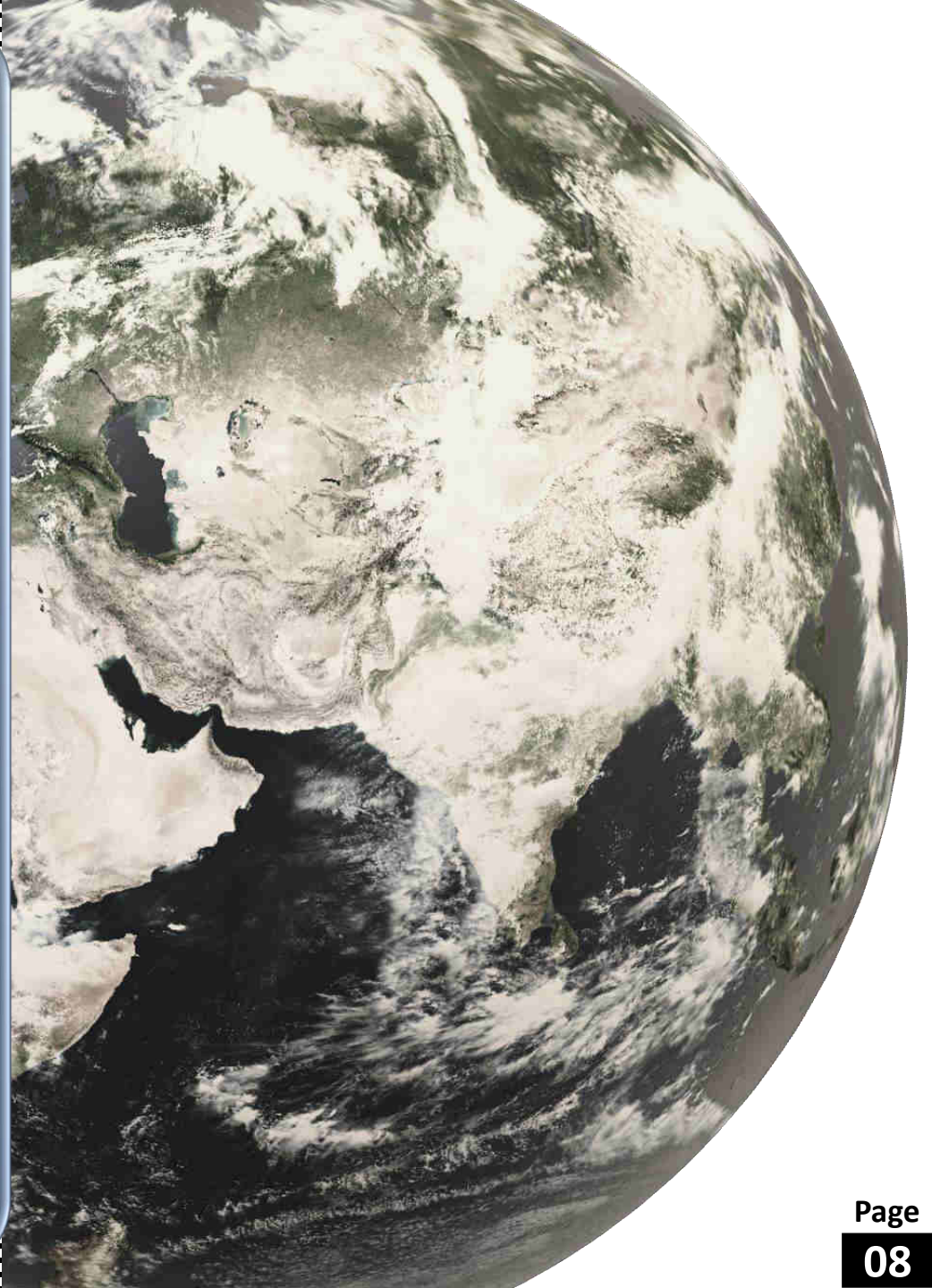
Projected Future Warming

Monitoring and Data

Regional Variations

Impacts of Warming

What is the risk of climate change ؟



ECO

National Cartographic Center of IRAN

RISK

Environmental Risks

Economic Risks

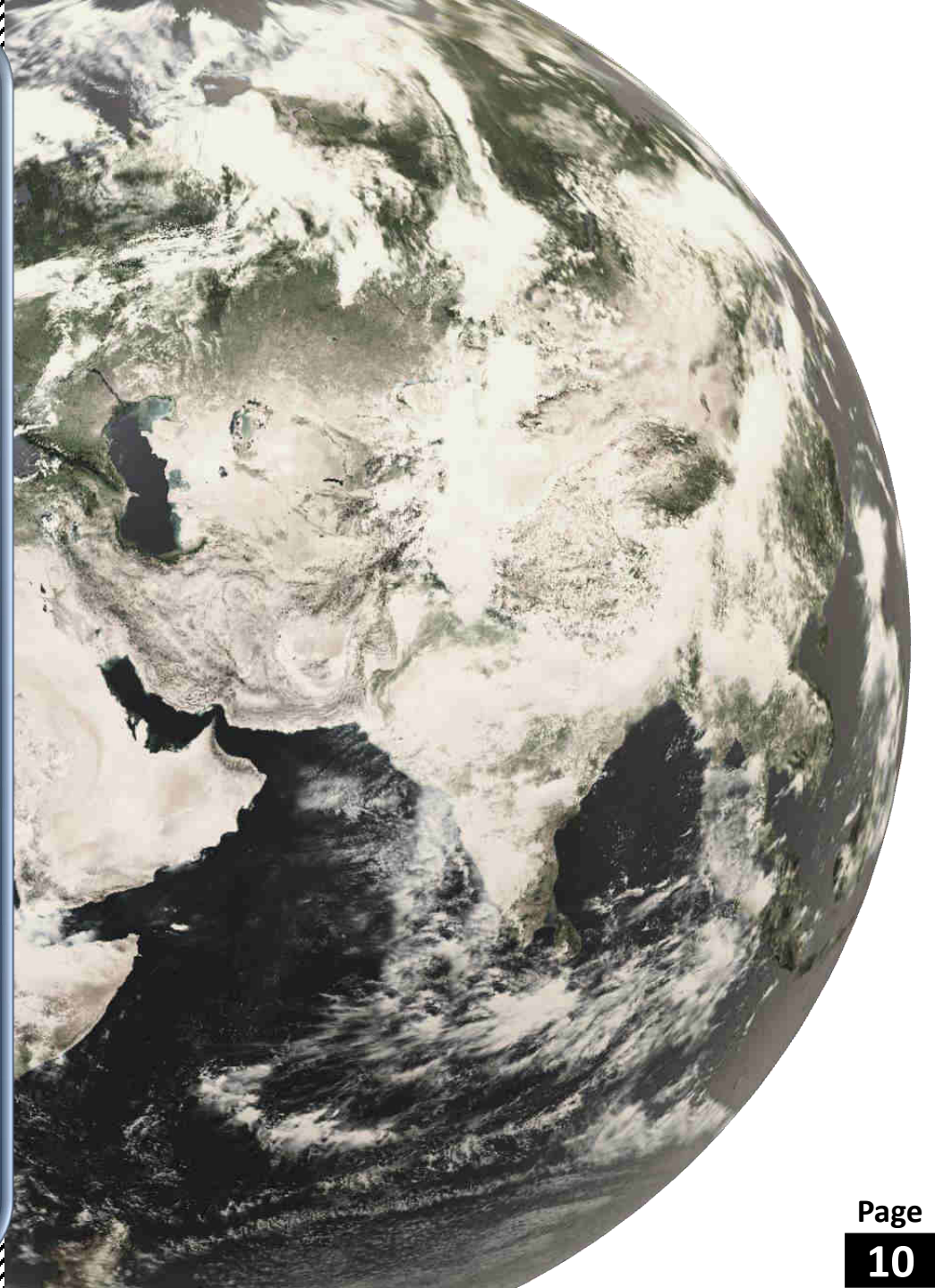
Geopolitical Risks

Health Risks

Social Risks

Feedback Loop

Why is there little action to mitigation climate change ؟



ECO

Challenges

National Cartographic Center of IRAN

- Political Challenges
- Social and Cultural Factors
- Inequities and Injustice
- Economic Factors
- Psychological Factors
- Complexity of Solutions

What
to
Do
؟

ECO

National Cartographic Center of IRAN

Actions

Individual Actions

Corporate Responsibility

Global Cooperation

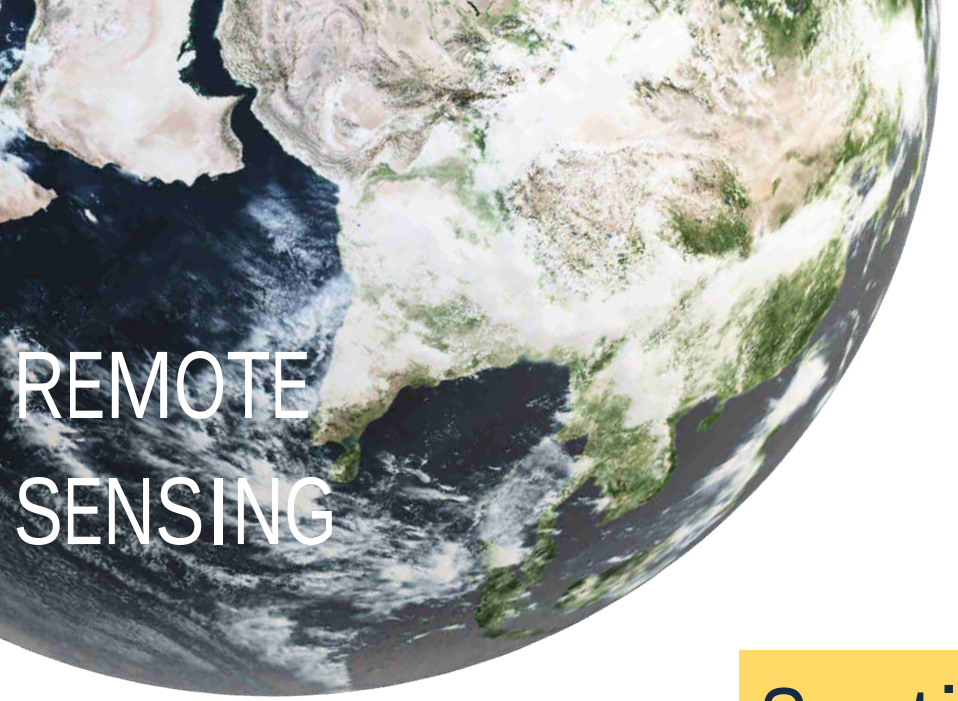
Community Initiatives

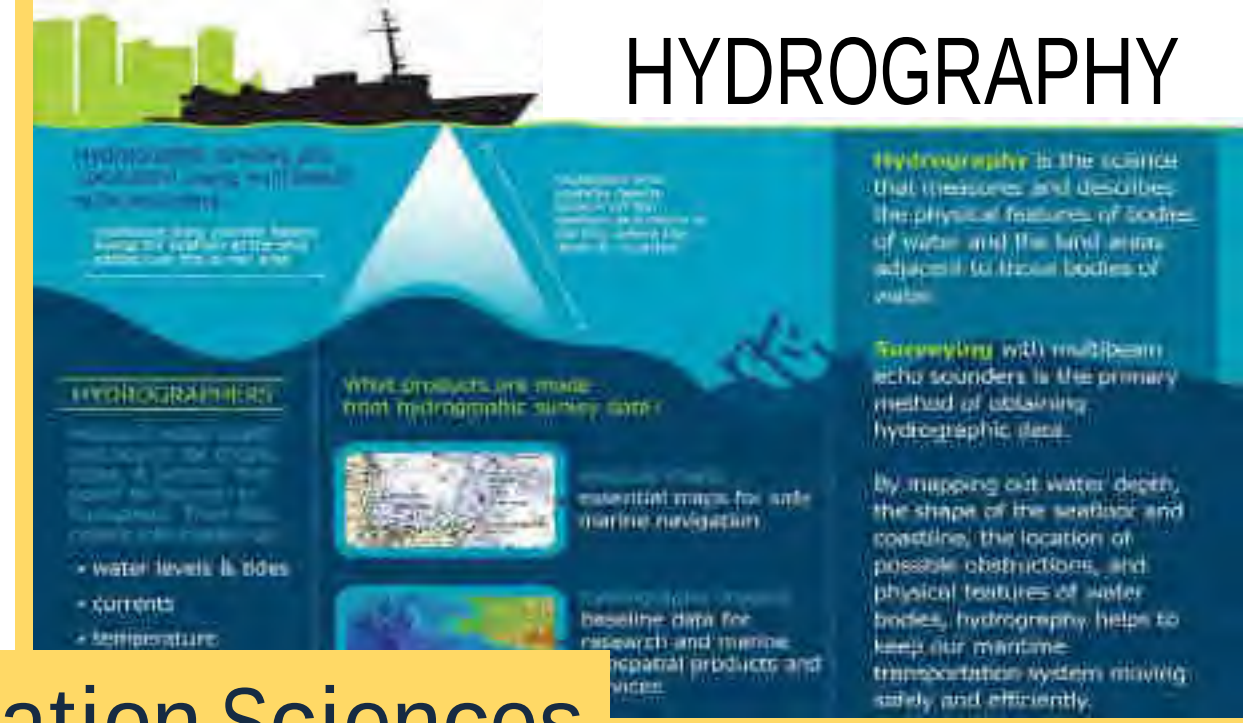
Government Policies

IPCC Reports

IPCC Sessions

ipcc
INTERGOVERNMENTAL PANEL ON climate change



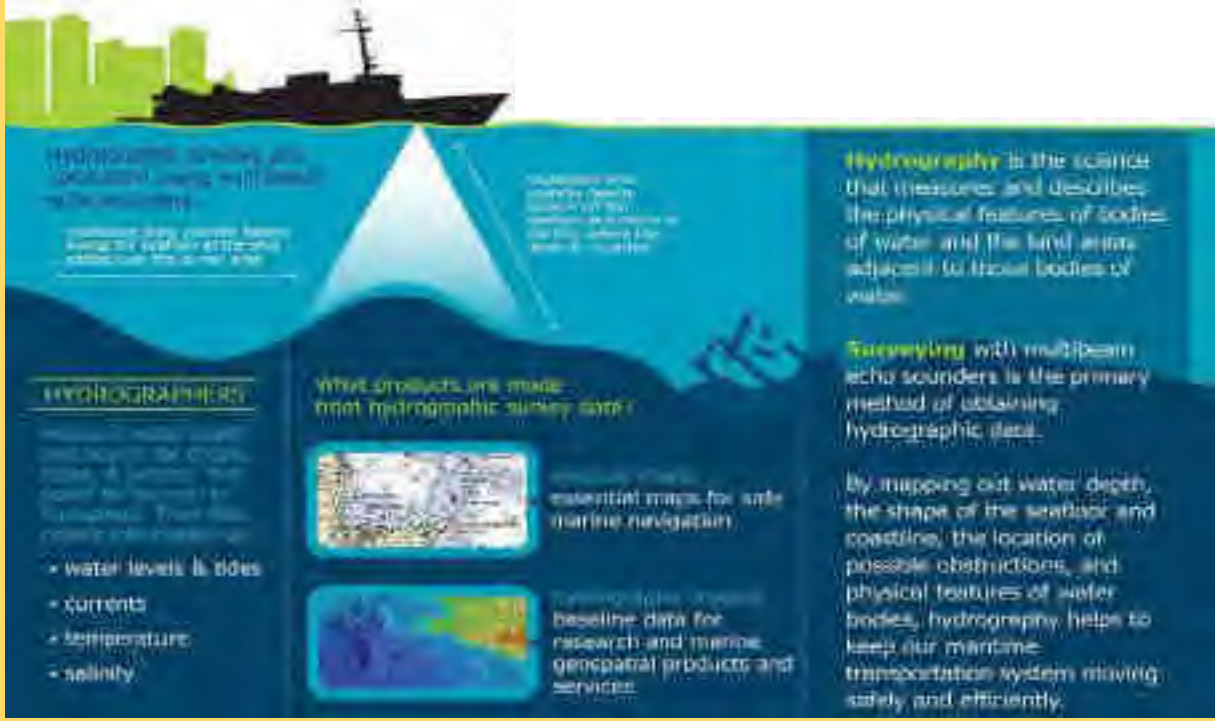


Spatial Information Sciences

REMOTE SENSING

1. Monitoring Climate Variables
2. Observing Land Use and Land Cover Changes
3. Carbon Cycle Monitoring
4. Extreme Weather Events
5. Climate Models and Projections

HYDROGRAPHY



1. Sea Level Rise:

2. Monitoring Water Resources

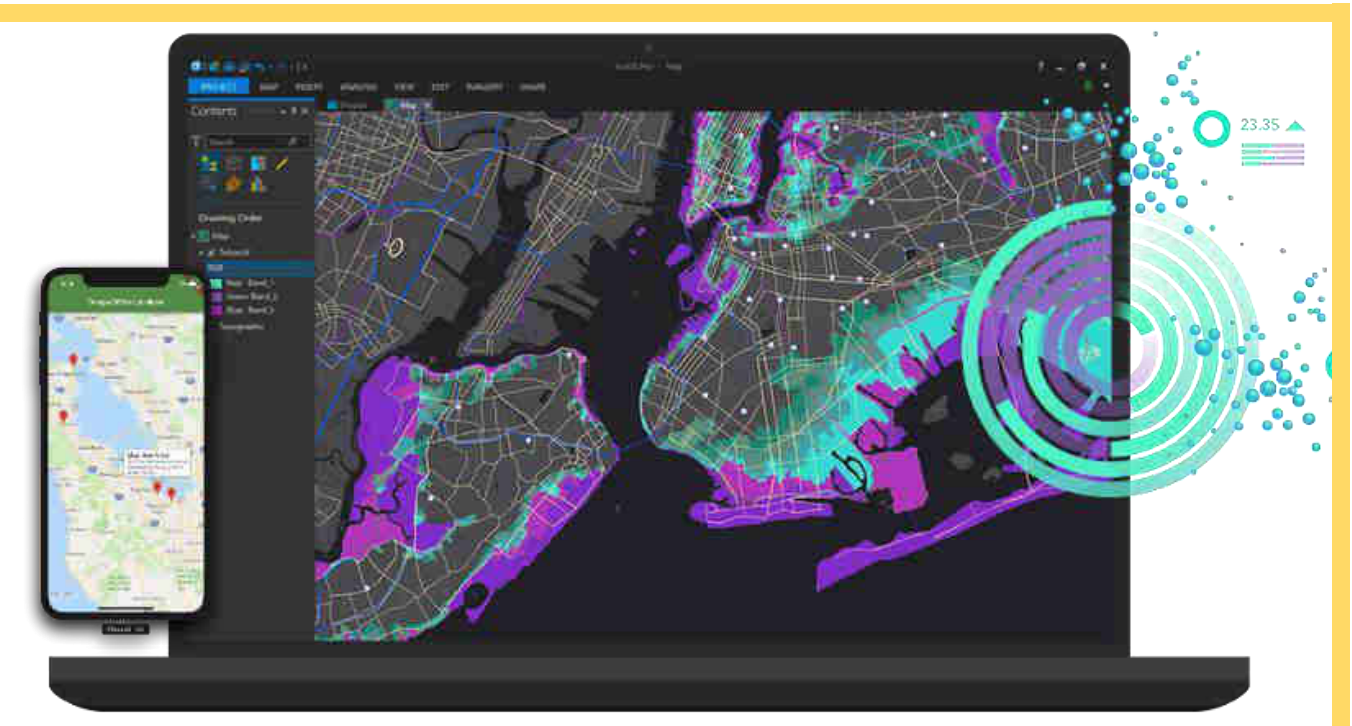
- Surface Water Levels
- Groundwater Levels

1. Data Integration and Analysis

2. Vulnerability and Impact Assessment

3. Land Use and Planning

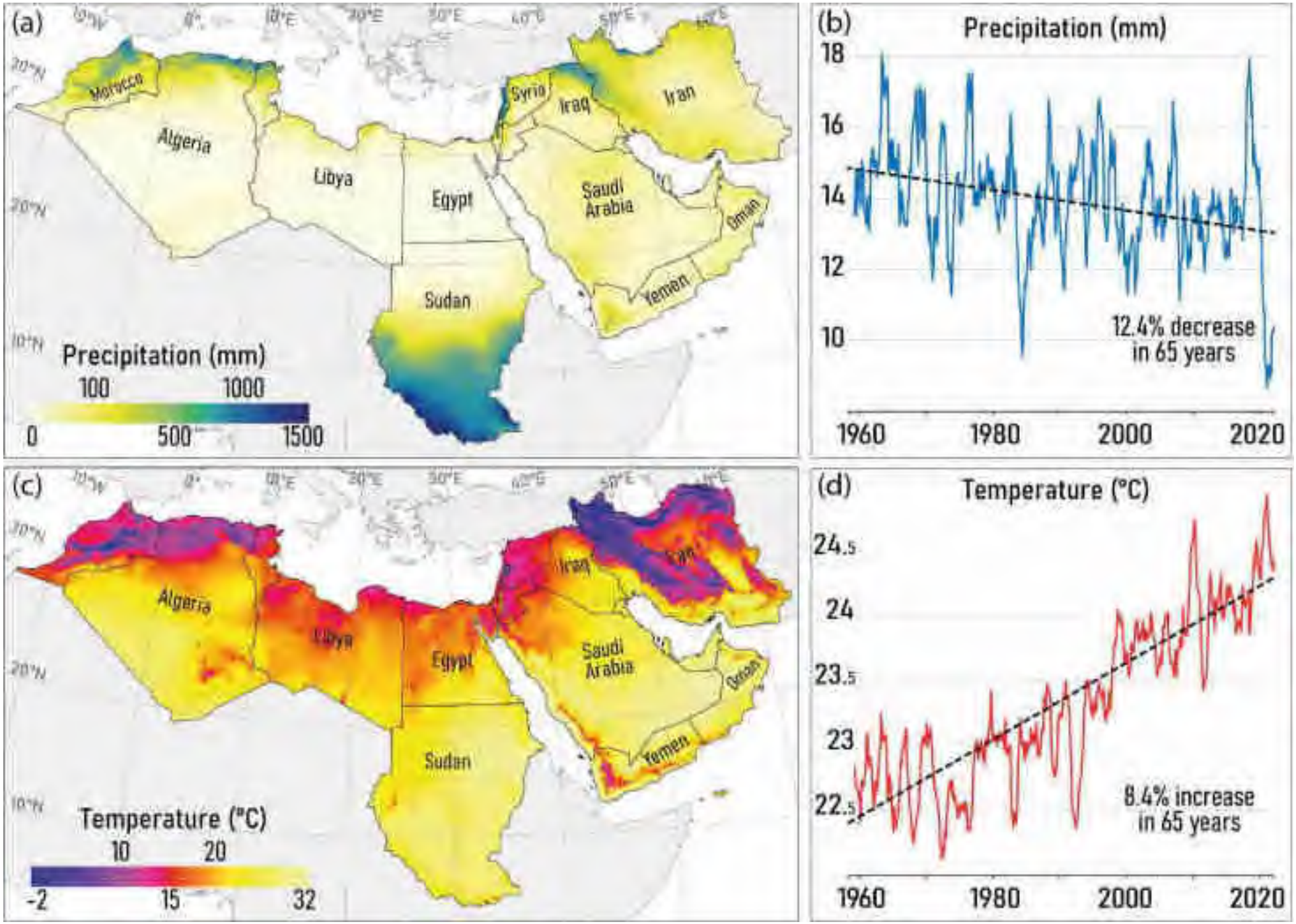
4. Disaster Risk Management

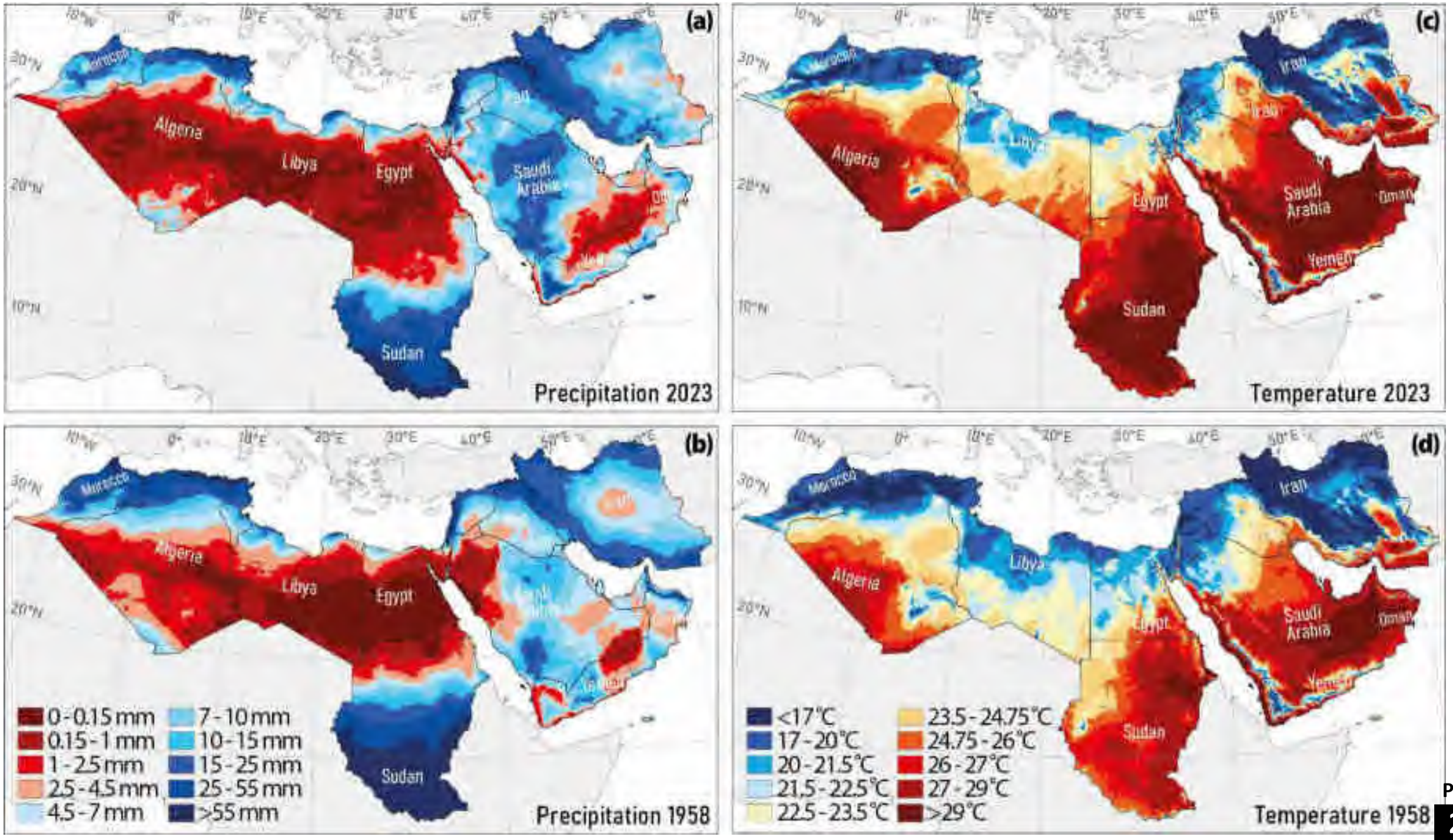


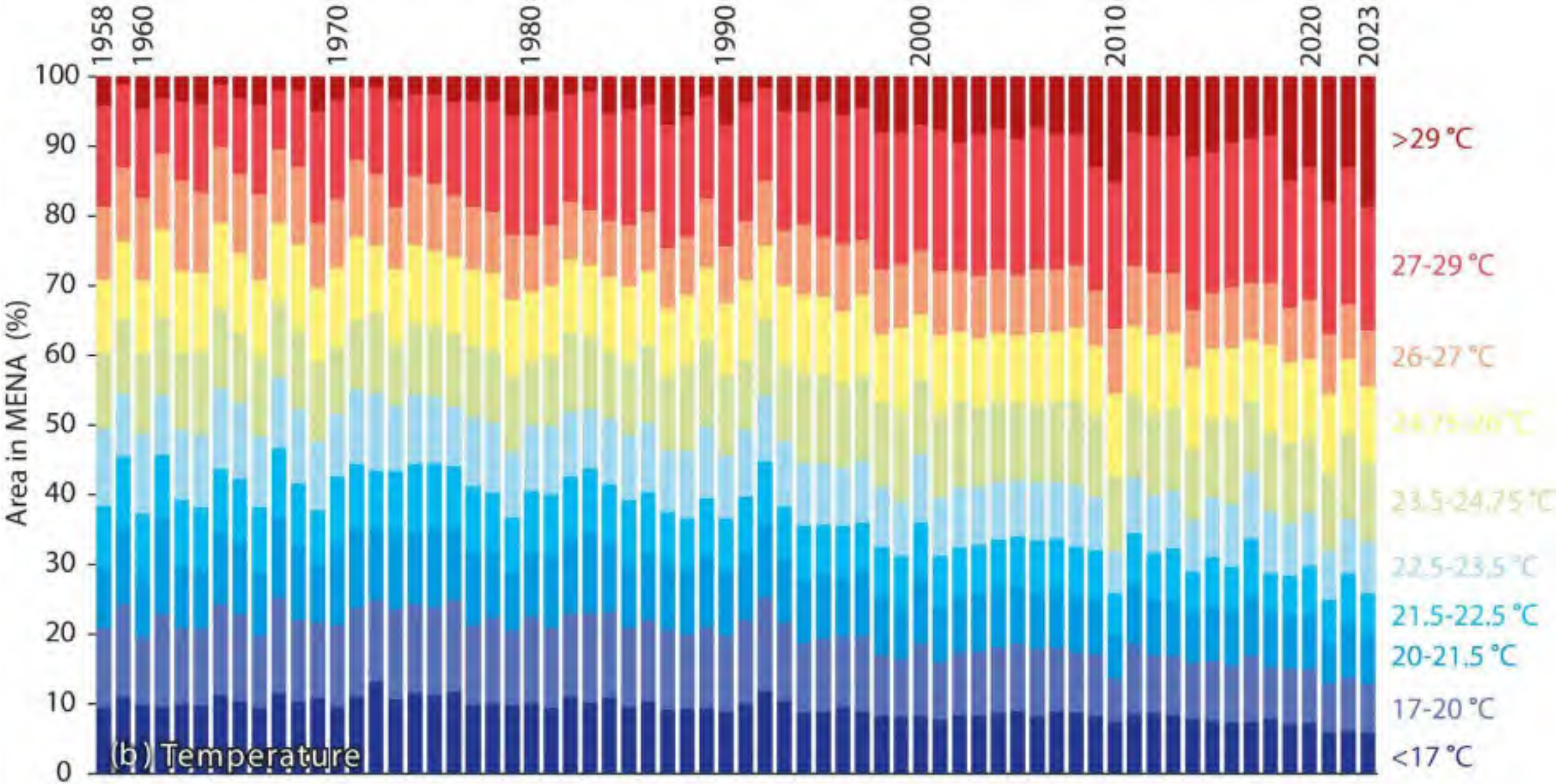
GIS

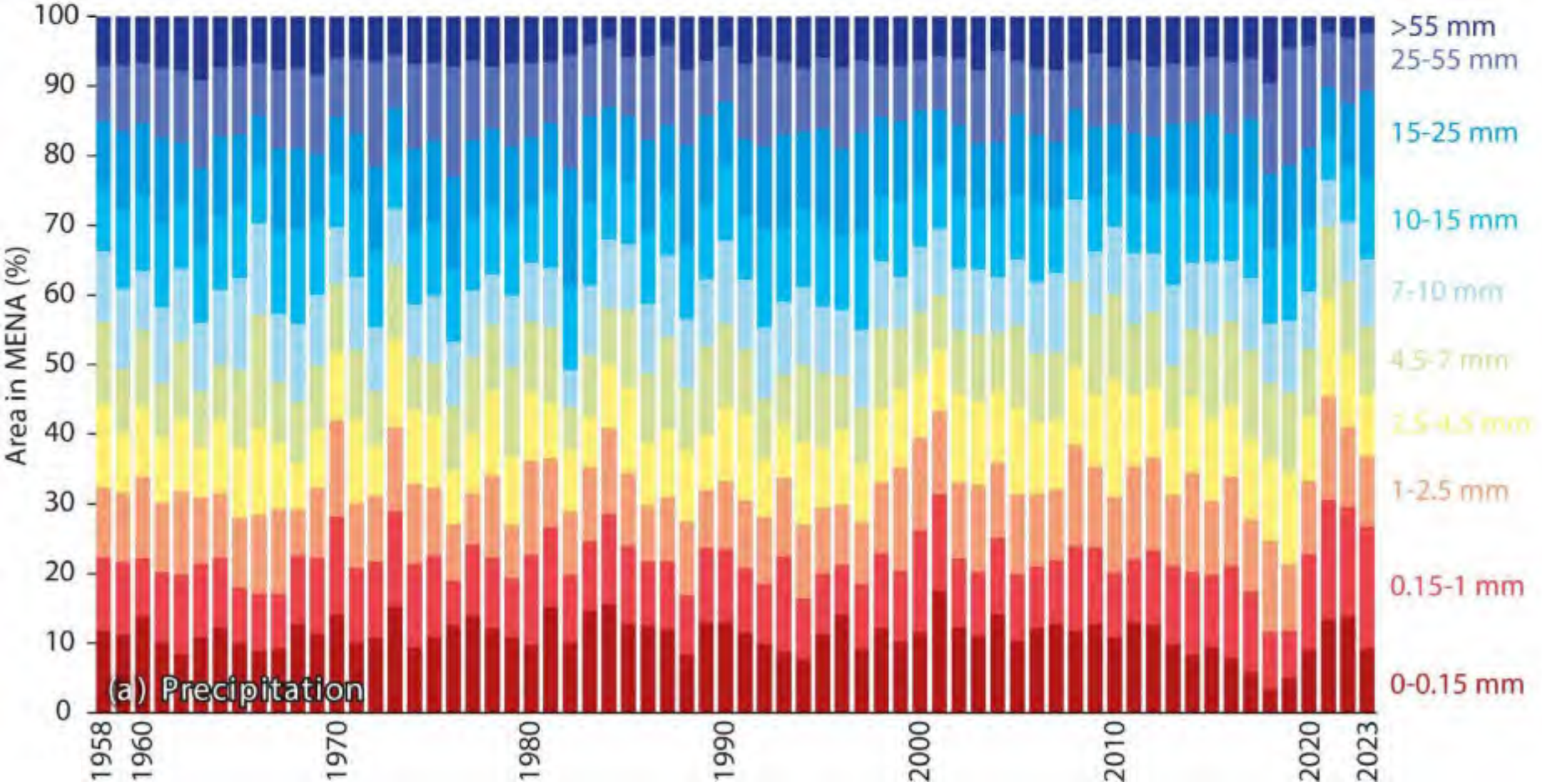
1. Data Representation
2. Understanding Spatial Relationships
3. Scenario Visualization
4. Public Engagement and Education
5. Technology and Tools

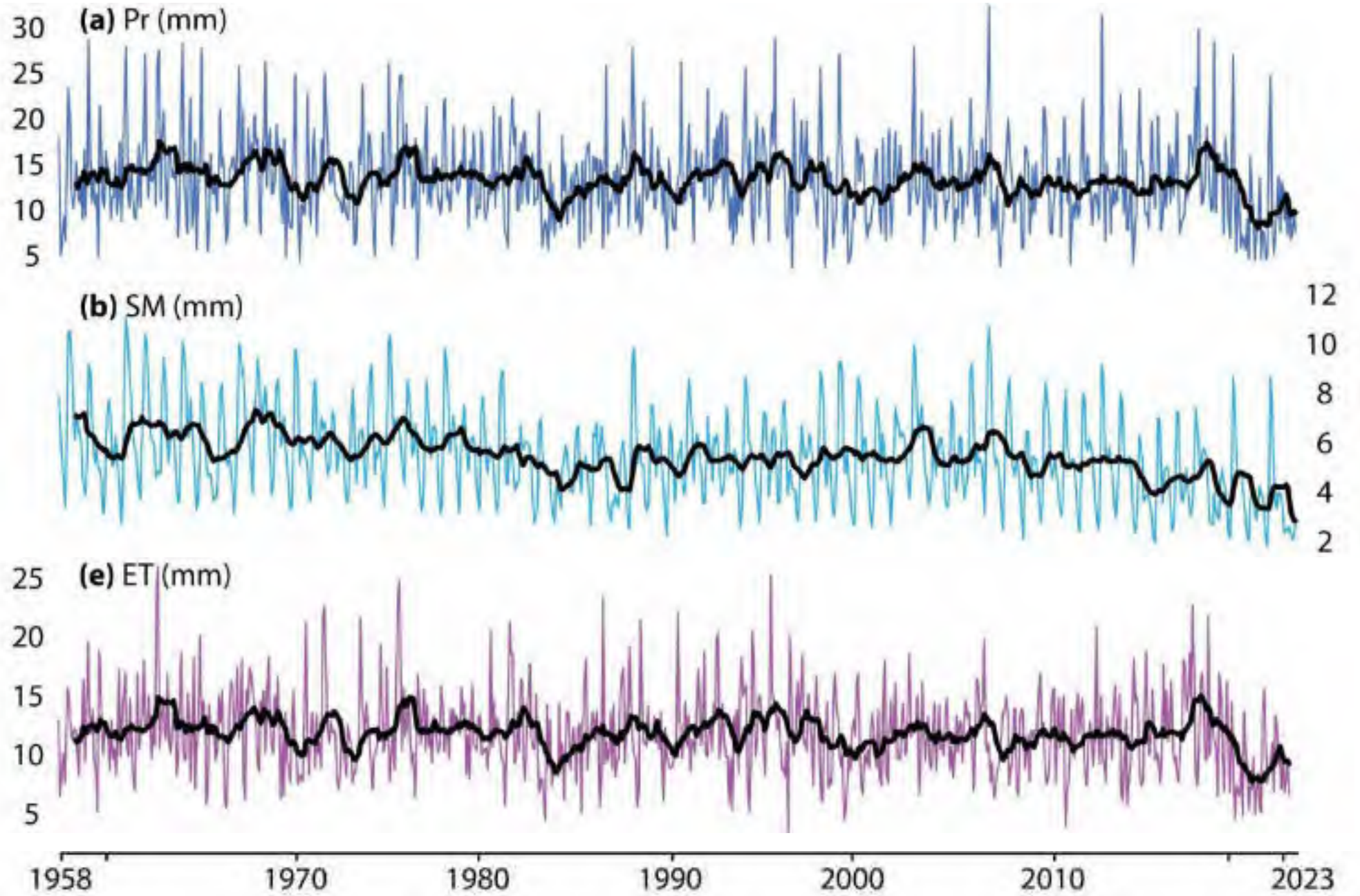
CARTOGRAPHY

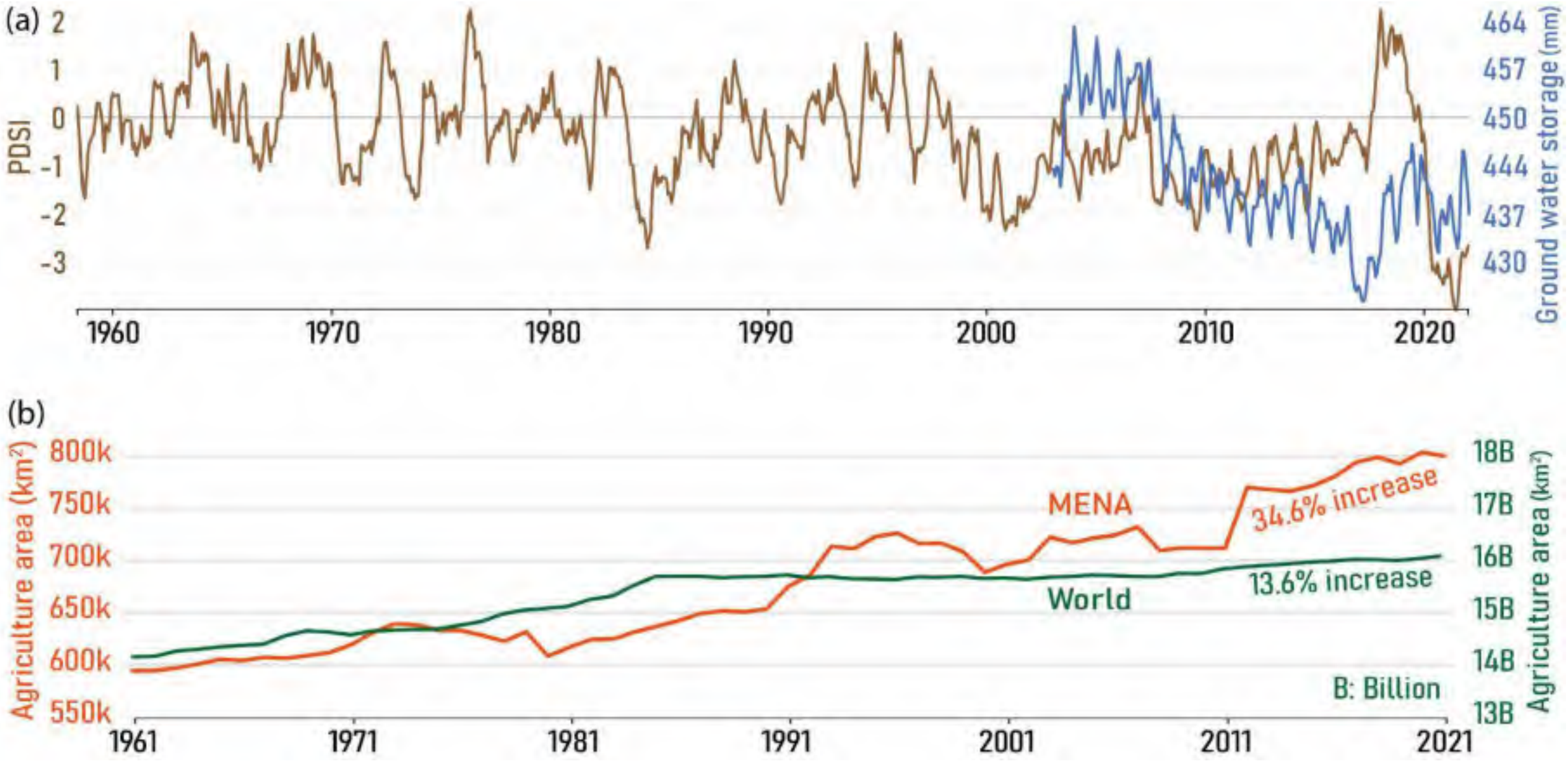

(a)
Morocco
Algeria
Libya
Egypt
Sudan
Syria
Iraq
Iran
Saudi Arabia
Oman
Yemen
Precipitation (mm)
100
1000
0
500
1500
(b)
Precipitation (mm)
18
16
14
12
10
12.4% decrease in 65 years
1960
1980
2000
2020
(c)
Temperature (°C)
10
20
-2
15
32
(d)
Temperature (°C)
24.5
24
23.5
23
22.5
8.4% increase in 65 years
1960
1980
2000
2020

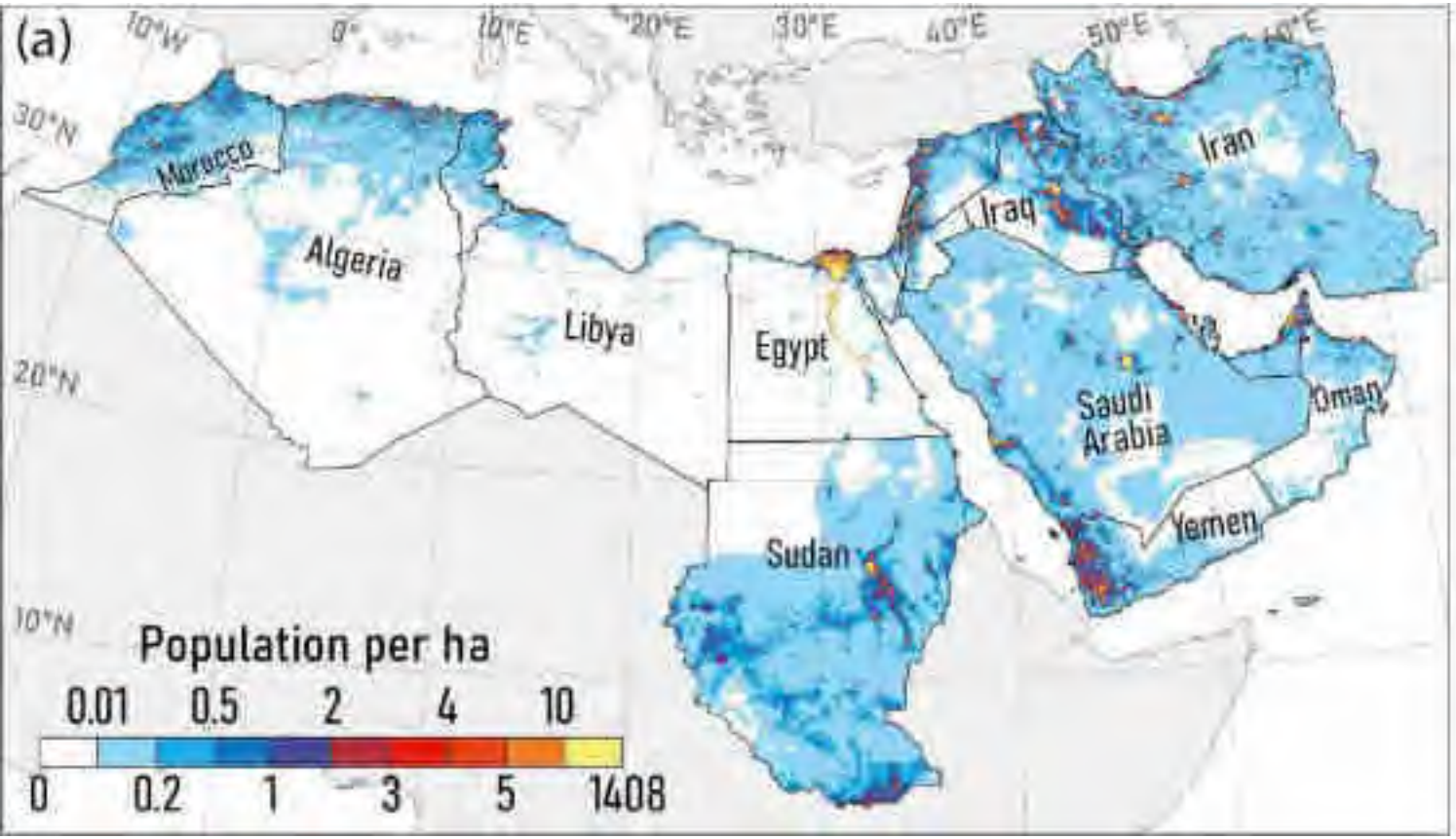

(a)
Algeria
Libya
Egypt
Saudi Arabia
Sudan
Precipitation 2023
(c)
Iran
Iraq
Algeria
Libya
Egypt
Saudi Arabia
Oman
Yemen
Sudan
Temperature 2023
(b)
Algeria
Libya
Egypt
Sudan
0-0.15 mm
0.15-1 mm
1-2.5 mm
2.5-4.5 mm
4.5-7 mm
7-10 mm
10-15 mm
15-25 mm
25-55 mm
>55 mm
Precipitation 1958
(d)
Iran
Algeria
Libya
Egypt
Saudi Arabia
Oman
Sudan
<17°C
17-20°C
20-21.5°C
21.5-22.5°C
22.5-23.5°C
23.5-24.75°C
24.75-26°C
26-27°C
27-29°C
>29°C
Temperature 1958

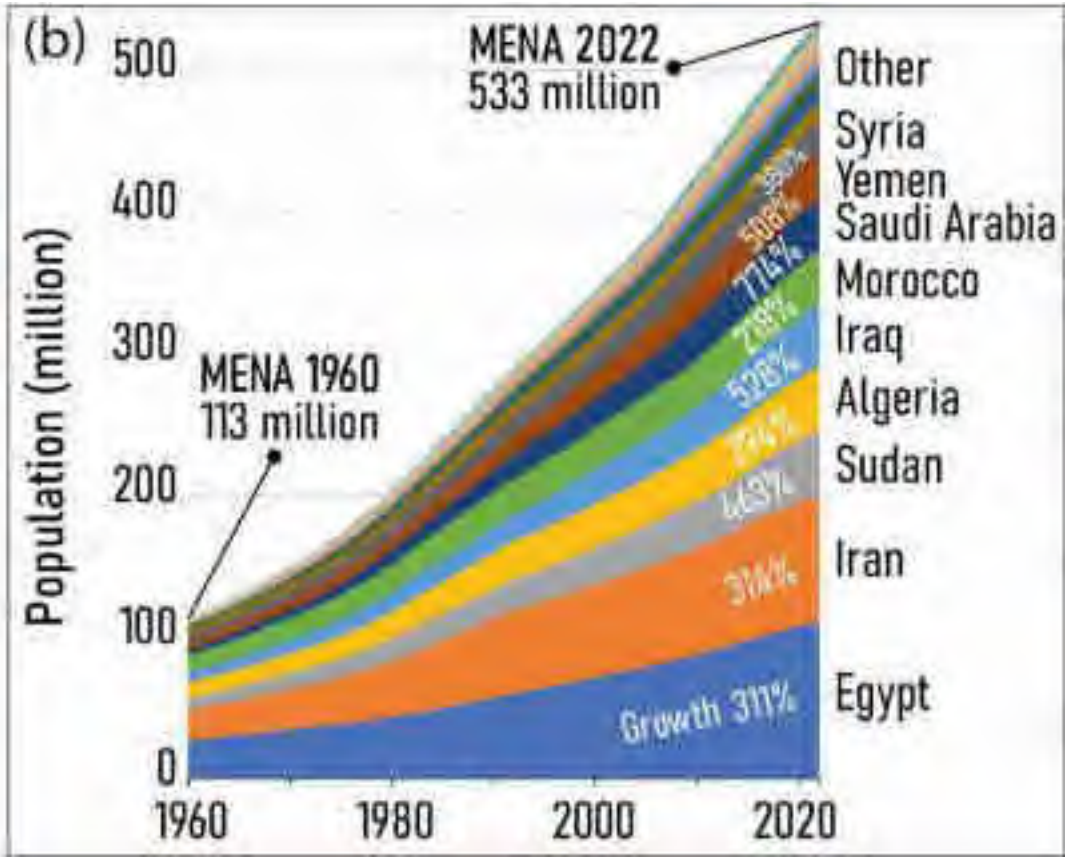

1958
1960
1970
1980
1990
2000
2010
2020
2023
100
90
80
70
60
50
40
30
20
10
0
Area in MENA (%)
(b) Temperature
>29 °C
27-29 °C
26-27 °C
24.75-26 °C
23.5-24.75 °C
22.5-23.5 °C
21.5-22.5 °C
20-21.5 °C
17-20 °C
<17 °C

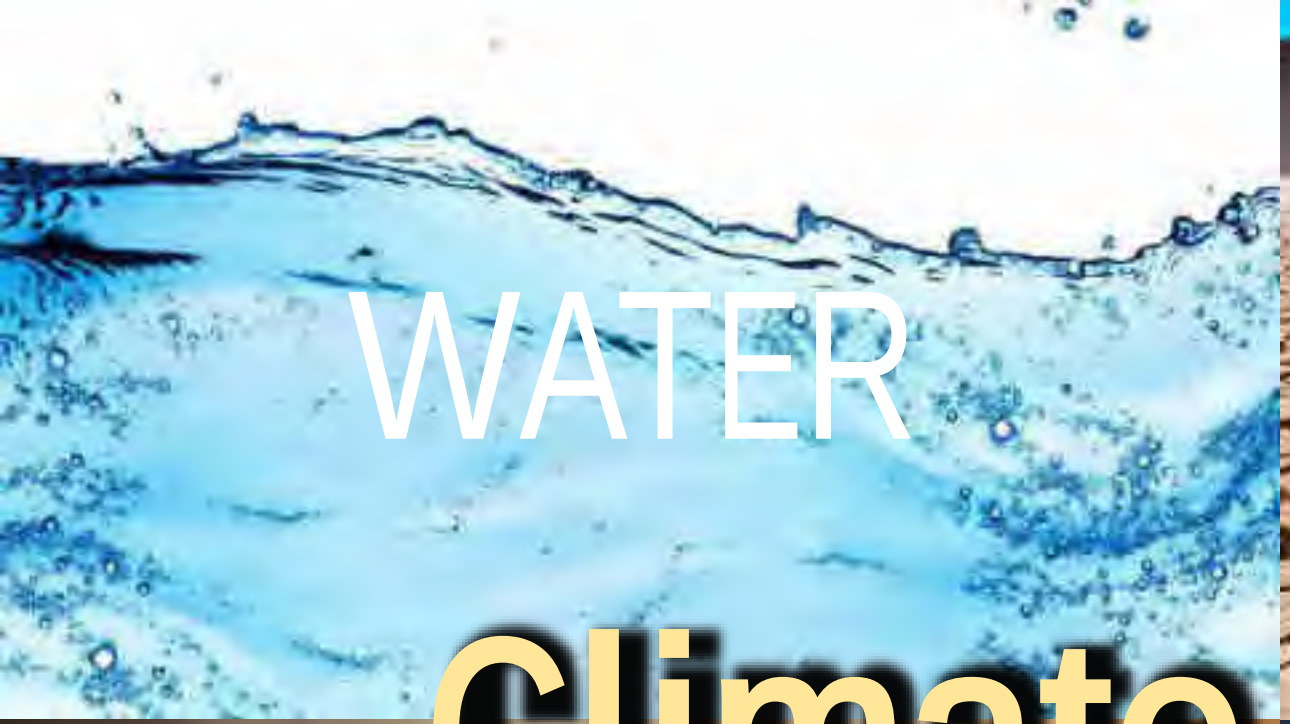

Area in MENA (%)
100
90
80
70
60
50
40
30
20
10
0
1958
1960
1970
1980
1990
2000
2010
2020
2023
(a) Precipitation
>55 mm
25-55 mm
15-25 mm
10-15 mm
7-10 mm
4.5-7 mm
2.5-4.5 mm
1-2.5 mm
0.15-1 mm
0-0.15 mm


(a) Pr (mm)
30
25
20
15
10
5
(b) SM (mm)
12
10
8
6
4
2
(e) ET (mm)
25
20
15
10
5
1958
1970
1980
1990
2000
2010
2023


(a)
PDSI
2
1
0
-1
-2
-3
1960
1970
1980
1990
2000
2010
2020
464
457
450
444
437
430
Ground water storage (mm)
(b)
Agriculture area (km²)
800k
750k
700k
650k
600k
550k
MENA
34.6% increase
World
13.6% increase
B: Billion
1961
1971
1981
1991
2001
2011
2021
18B
17B
16B
15B
14B
13B
Agriculture area (km²)

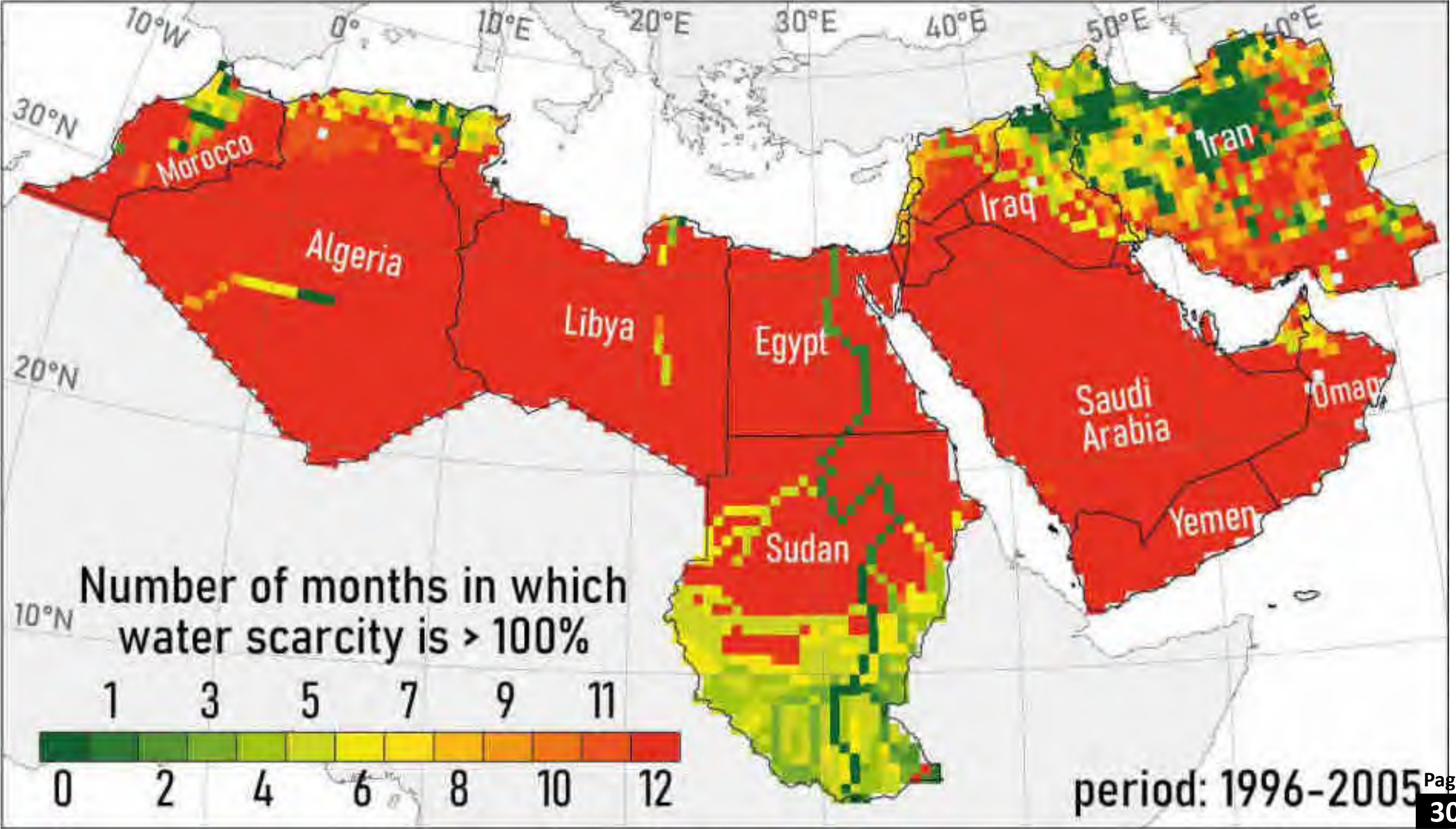

(a)
10°W
0°
10°E
20°E
30°E
40°E
50°E
60°E
30°N
20°N
10°N
Morocco
Algeria
Libya
Egypt
Iraq
Iran
Saudi Arabia
Oman
Yemen
Sudan
Population per ha
0.01
0.5
2
4
10
0
0.2
1
3
5
1408


(b)
Population (million)
500
400
300
200
100
0
1960
1980
2000
2020
MENA 2022
533 million
MENA 1960
113 million
Other
Syria
Yemen
Saudi Arabia
Morocco
Iraq
Algeria
Sudan
Iran
Egypt
Growth 311%



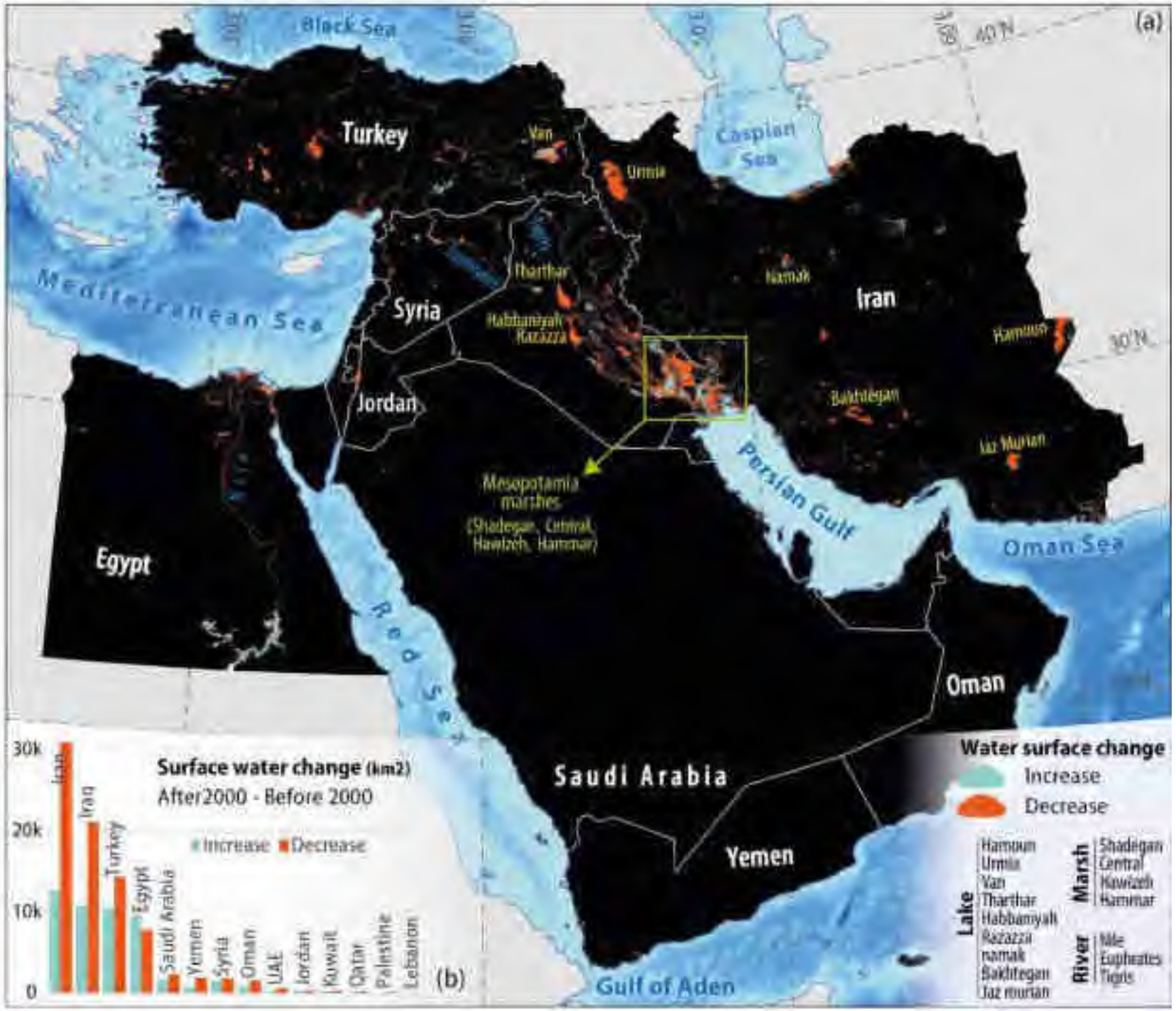
Climate Change

Climate change


10°W
0°
10°E
20°E
30°E
40°E
50°E
60°E
30°N
20°N
10°N
Morocco
Algeria
Libya
Egypt
Sudan
Iraq
Iran
Saudi Arabia
Yemen
Oman
Number of months in which water scarcity is > 100%
1 3 5 7 9 11
0 2 4 6 8 10 12
period: 1996-2005

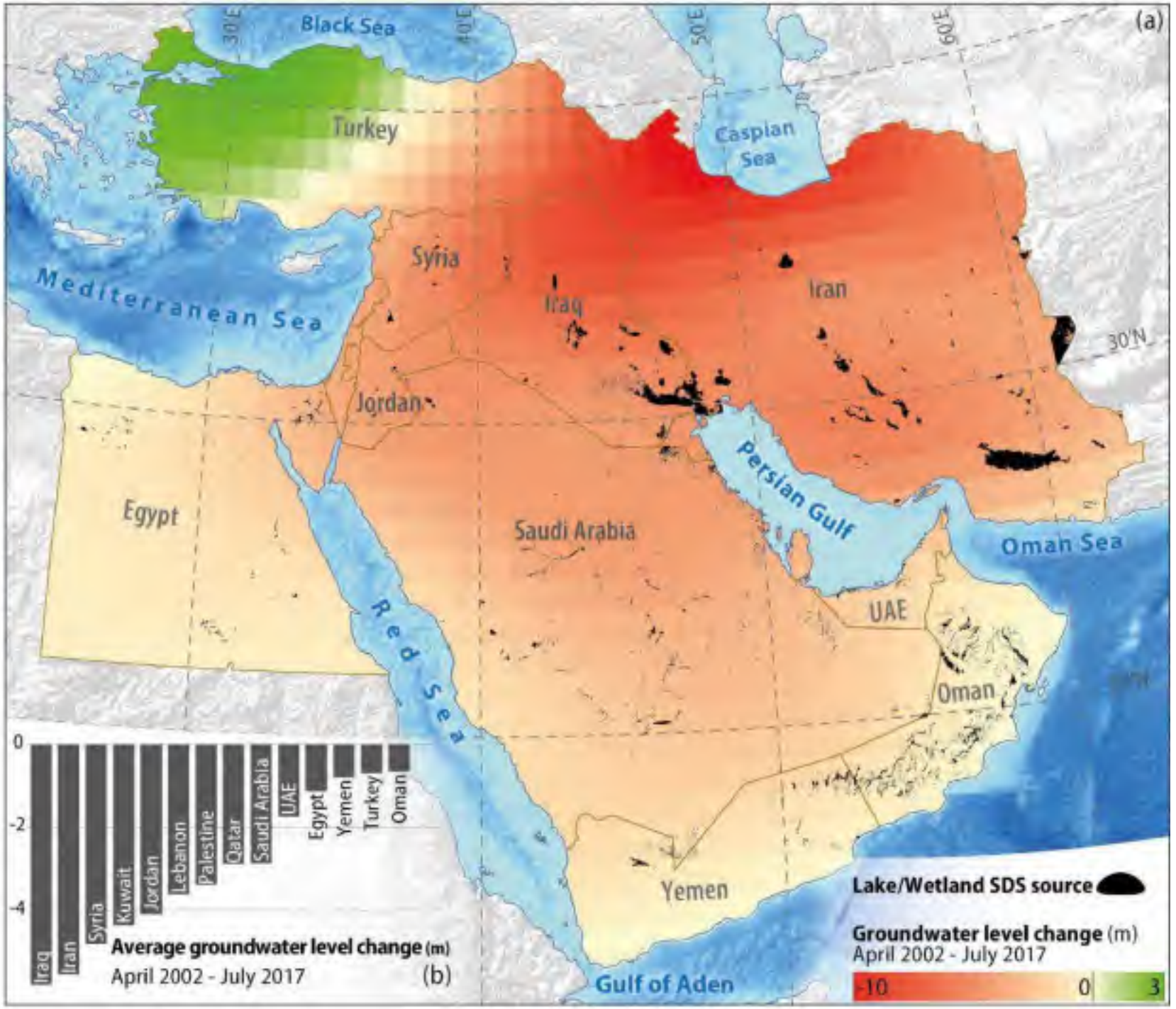
ECO

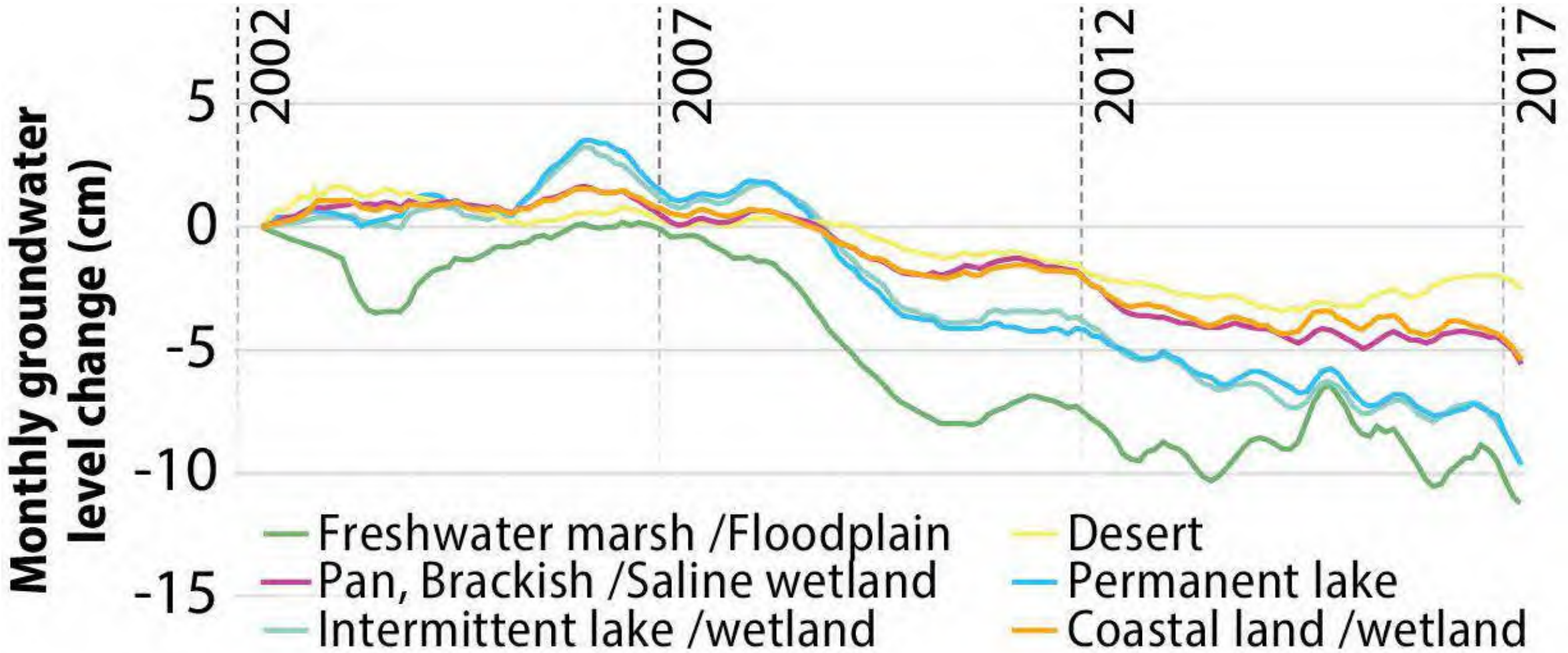
National Cartographic Center of IRAN



ECO

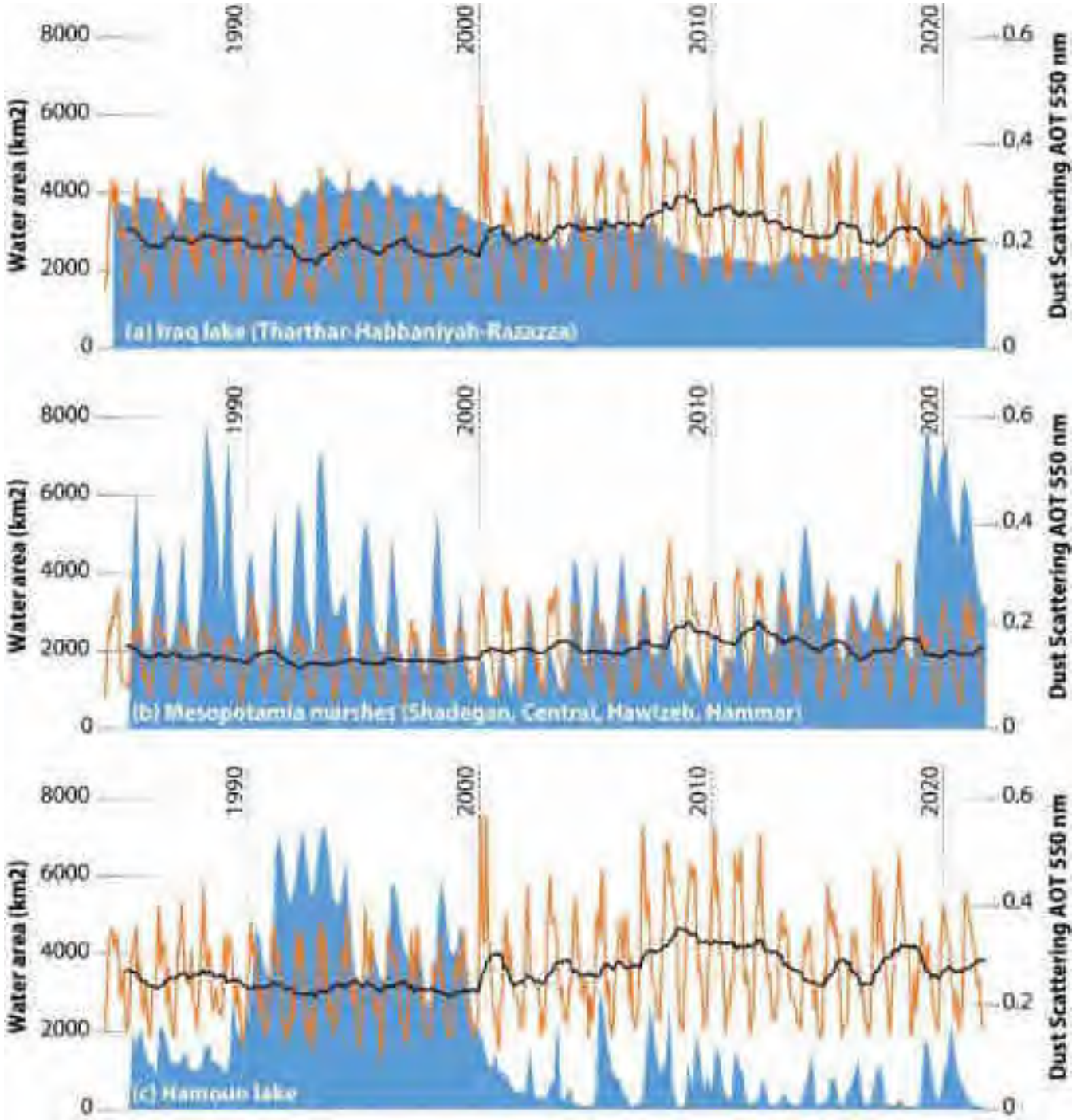
National Cartographic Center of IRAN

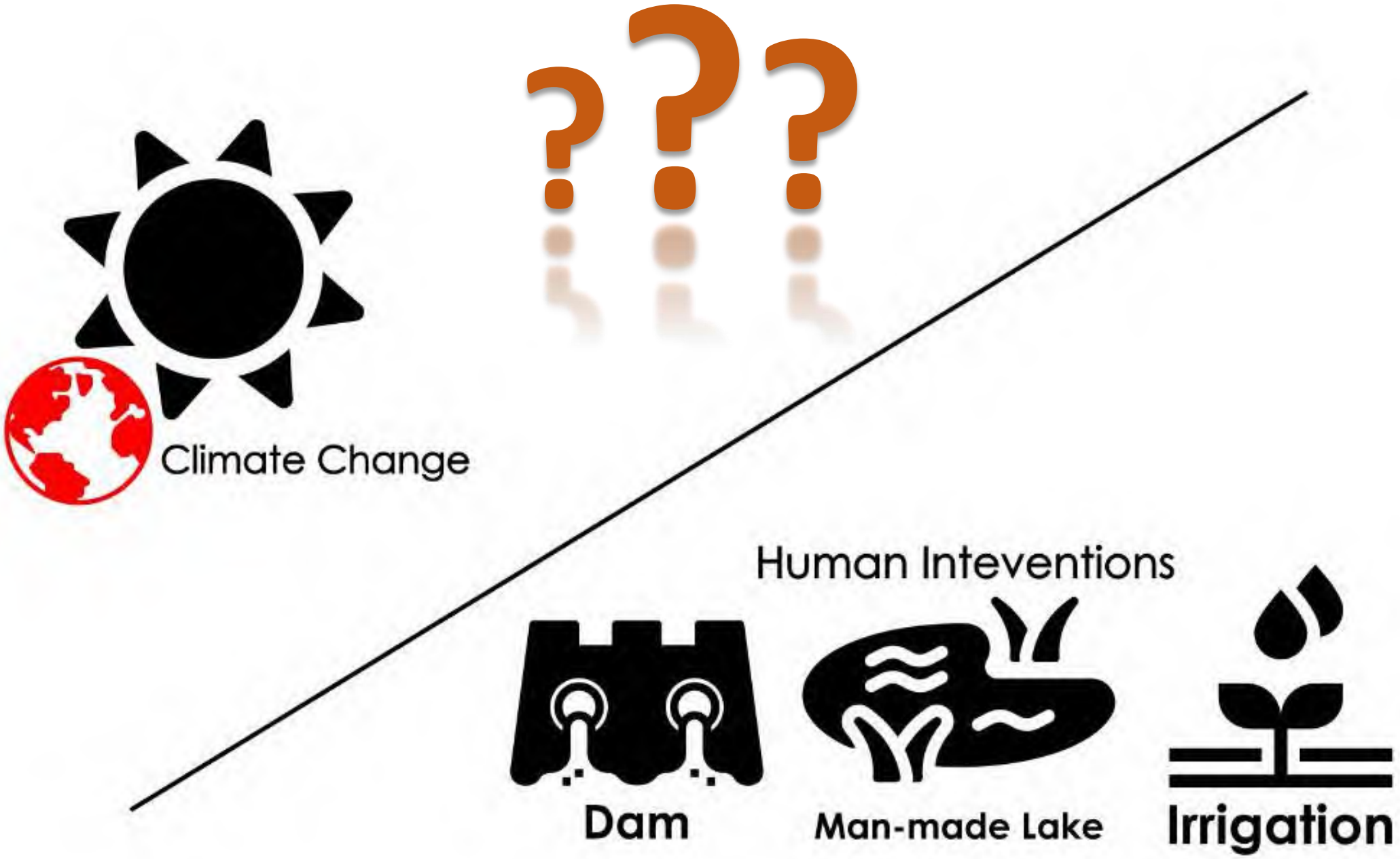


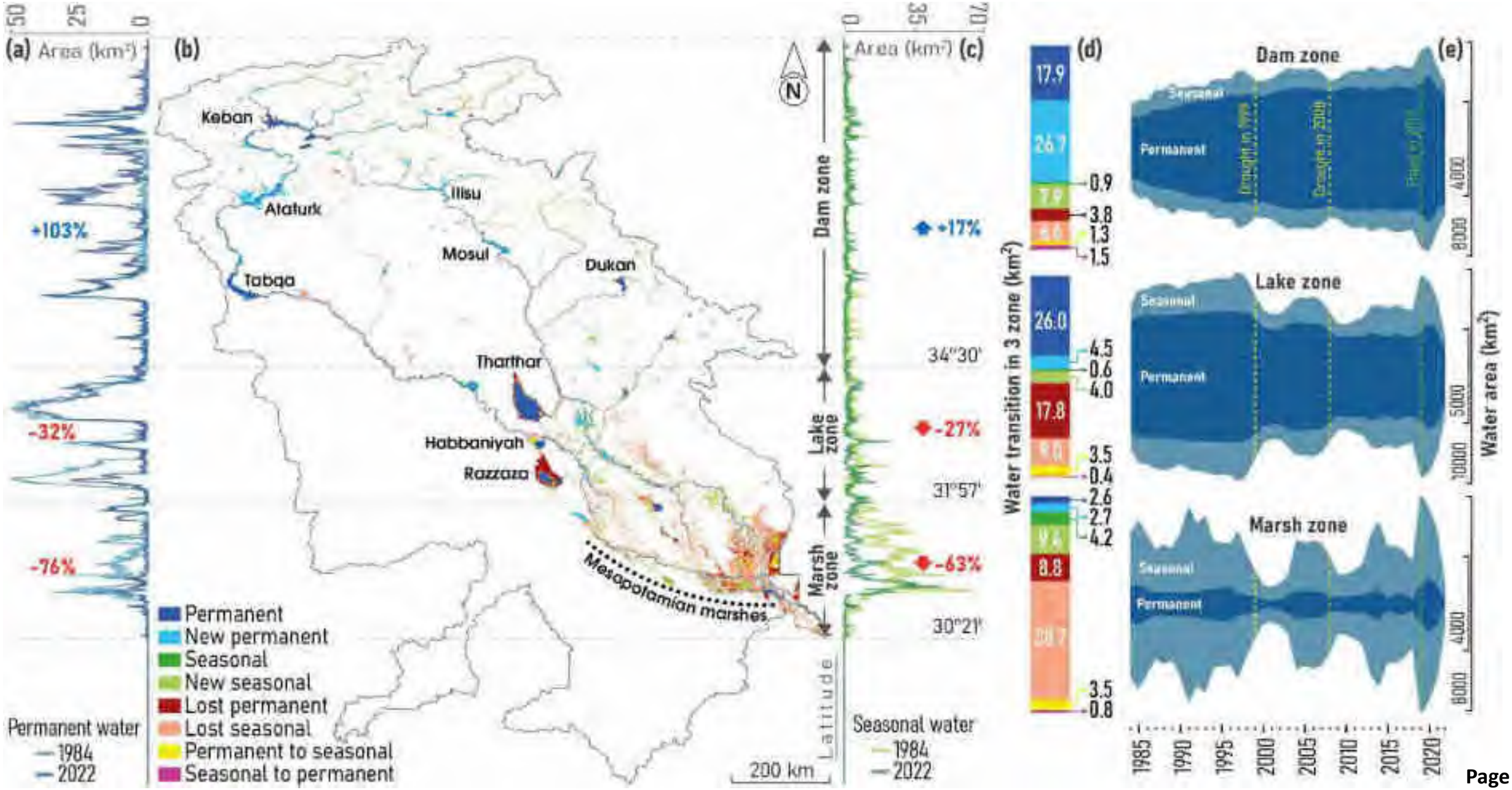

Monthly groundwater level change (cm)
5
0
-5
-10
-15
2002
2007
2012
2017
Freshwater marsh /Floodplain
Pan, Brackish /Saline wetland
Intermittent lake /wetland
Desert
Permanent lake
Coastal land /wetland

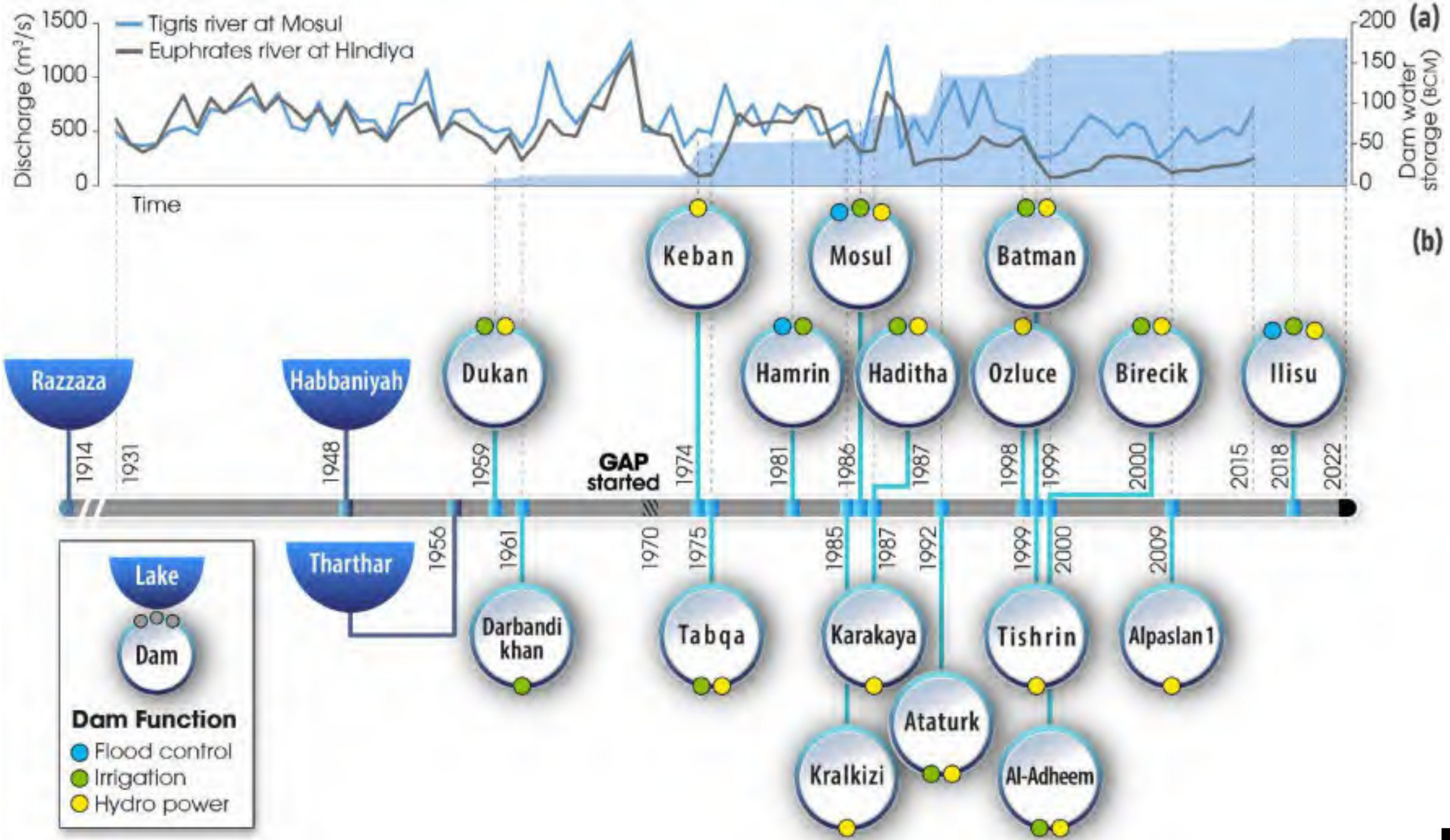
ECO

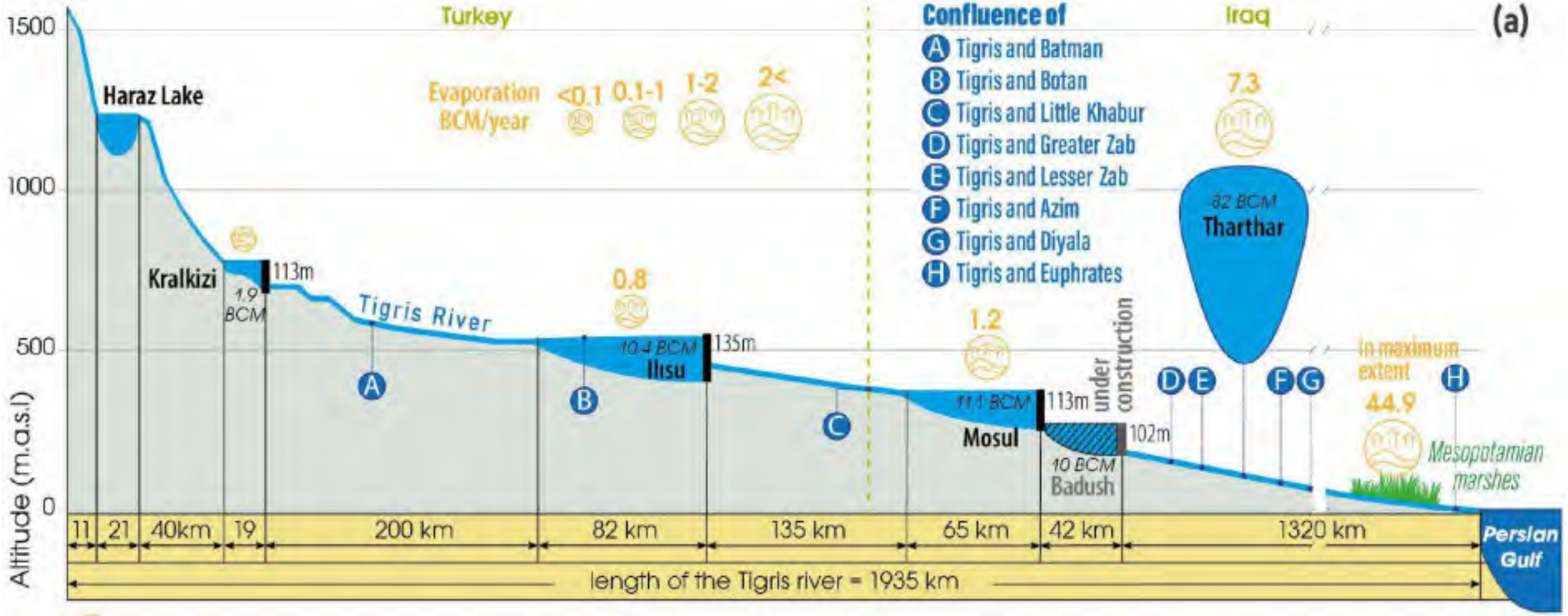
National Cartographic Center of IRAN

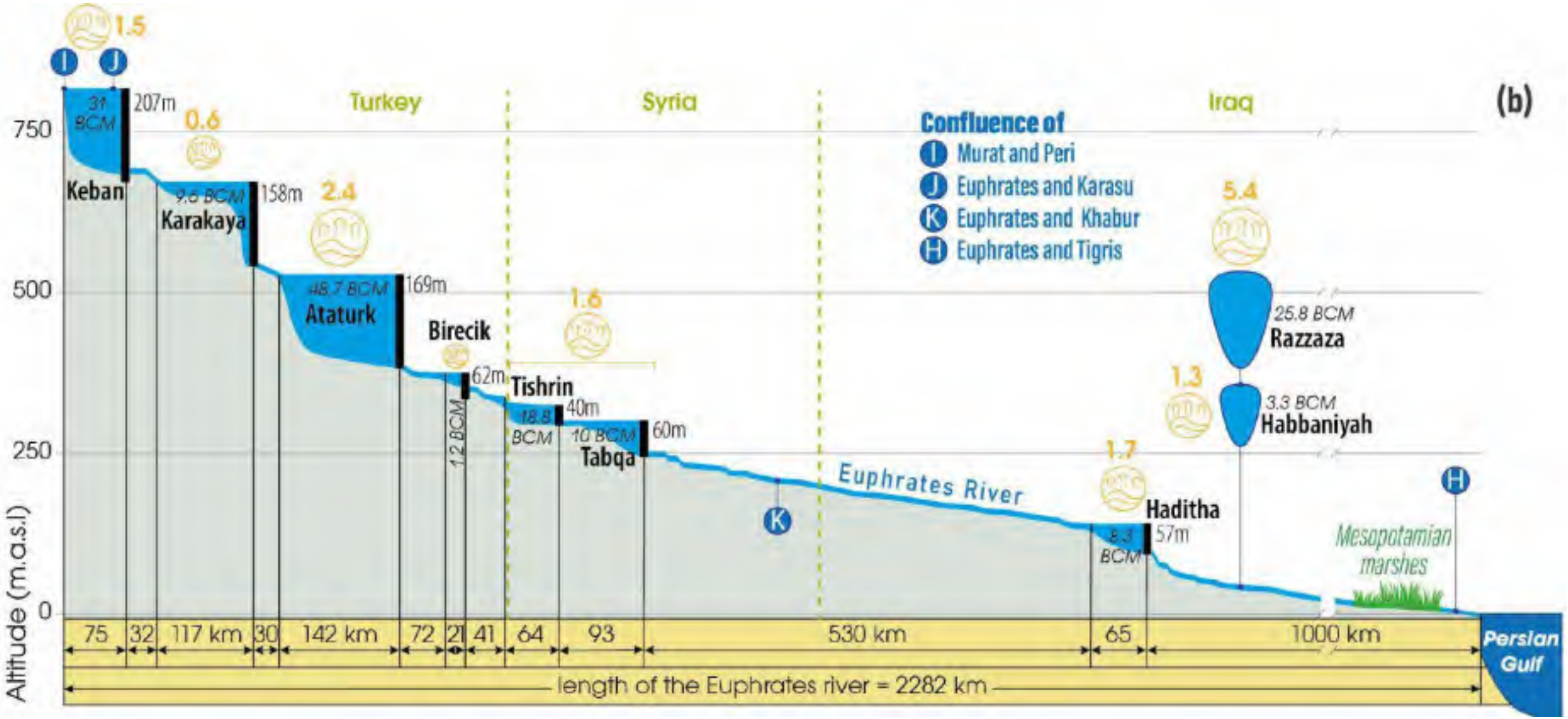


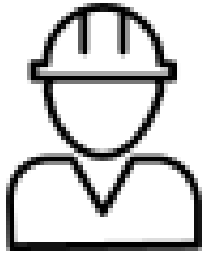

???
Climate Change
Human Inteventions
Dam
Man-made Lake
Irrigation


(a) Area (km²)
150
25
0
+103%
-32%
-76%
Permanent water
1984
2022
(b)
Keban
Atatürk
Tabqa
Ilisu
Mosul
Dukan
Tharthar
Habbaniyah
Razzaza
Mesopotamian marshes
Permanent
New permanent
Seasonal
New seasonal
Lost permanent
Lost seasonal
Permanent to seasonal
Seasonal to permanent
200 km
Latitude
Area (km²) (c)
0
35
70
Dam zone
Lake zone
Marsh zone
+17%
-27%
-63%
34°30'
31°57'
30°21'
Seasonal water
1984
2022
(d)
Water transition in 3 zone (km²)
17.9
26.7
7.9
4.6
0.9
3.8
1.3
1.5
26.0
17.8
9.0
4.5
0.6
4.0
3.5
0.4
9.4
8.8
28.7
2.6
2.7
4.2
3.5
0.8
(e)
Dam zone
Lake zone
Marsh zone
Seasonal
Permanent
Drought in 1999
Drought in 2018
Flood in 2019
Water area (km²)
4000
8000
5000
10000
6000
1985
1990
1995
2000
2005
2010
2015
2020


Discharge (m³/s)
1500
1000
500
0
Tigris river at Mosul
Euphrates river at Hindiya
Time
200
150
100
50
0
Dam water storage (BCM)
(a)
(b)
Keban
Mosul
Batman
Razzaza
Habbaniyah
Dukan
Hamrin
Haditha
Ozluce
Birecik
Ilisu
1914
1931
1948
1959
GAP started
1974
1981
1986
1987
1998
1999
2000
2015
2018
2022
Tharthar
1956
1961
1970
1975
1985
1987
1992
1999
2000
2009
Darbandi khan
Tabqa
Karakaya
Tishrin
Alpaslan 1
Ataturk
Kralkizi
Al-Adheem
Lake
Dam
Dam Function
Flood control
Irrigation
Hydro power


(a)
Turkey
Iraq
Confluence of
A Tigris and Batman
B Tigris and Botan
C Tigris and Little Khabur
D Tigris and Greater Zab
E Tigris and Lesser Zab
F Tigris and Azim
G Tigris and Diyala
H Tigris and Euphrates
Evaporation BCM/year
<0.1
0.1-1
1-2
2<
1500
1000
500
0
Altitude (m.a.s.l)
Haraz Lake
Kralkizi
1.9 BCM
113m
Tigris River
0.8
10.4 BCM
Ilisu
135m
1.2
11.1 BCM
Mosul
113m
under construction
10 BCM
Badush
102m
7.3
32 BCM
Tharthar
In maximum extent
44.9
Mesopotamian marshes
Persian Gulf
11
21
40km
19
200 km
82 km
135 km
65 km
42 km
1320 km
length of the Tigris river = 1935 km


(b)
Turkey
Syria
Iraq
Confluence of
I Murat and Peri
J Euphrates and Karasu
K Euphrates and Khabur
H Euphrates and Tigris
1.5
31 BCM
207m
Keban
0.6
9.6 BCM
158m
Karakaya
2.4
48.7 BCM
169m
Ataturk
Birecik
62m
1.6
Tishrin
18.8 BCM
40m
10 BCM
60m
Tabqa
1.2 BCM
Euphrates River
5.4
25.8 BCM
Razzaza
1.3
3.3 BCM
Habbaniyah
1.7
8.3 BCM
57m
Haditha
Mesopotamian marshes
Persian Gulf
Altitude (m.a.s.l)
750
500
250
0
75
32
117 km
30
142 km
72
21
41
64
93
530 km
65
1000 km
length of the Euphrates river = 2282 km



15.3 %

+

8.2 %

+

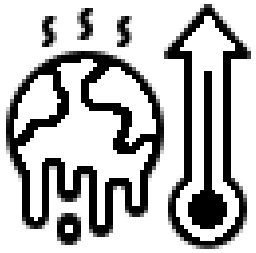
15.8 %

Dam

Agriculture

Artificial lake

Human



Precipitation

9.6 %

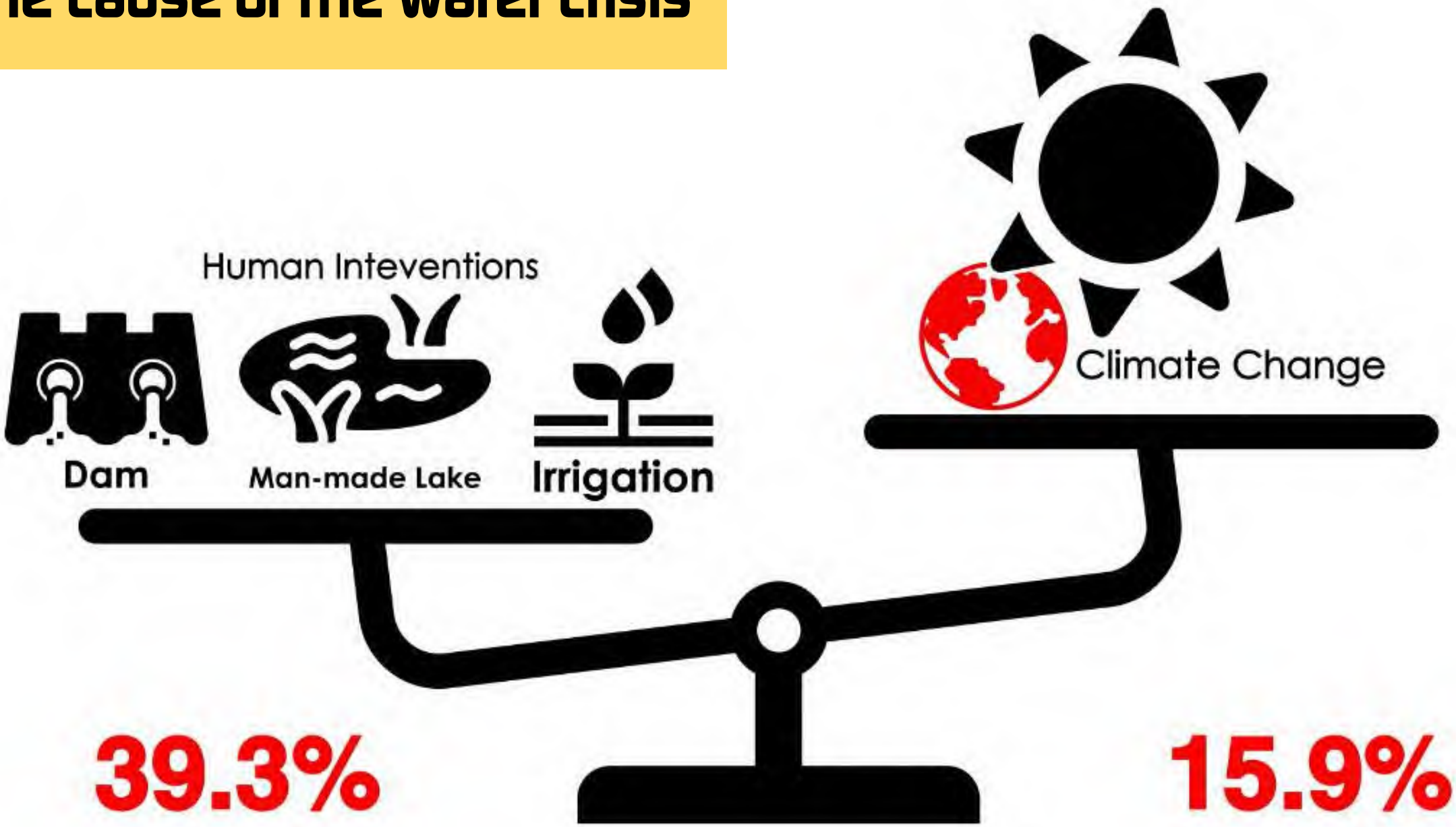
+

Evaporation

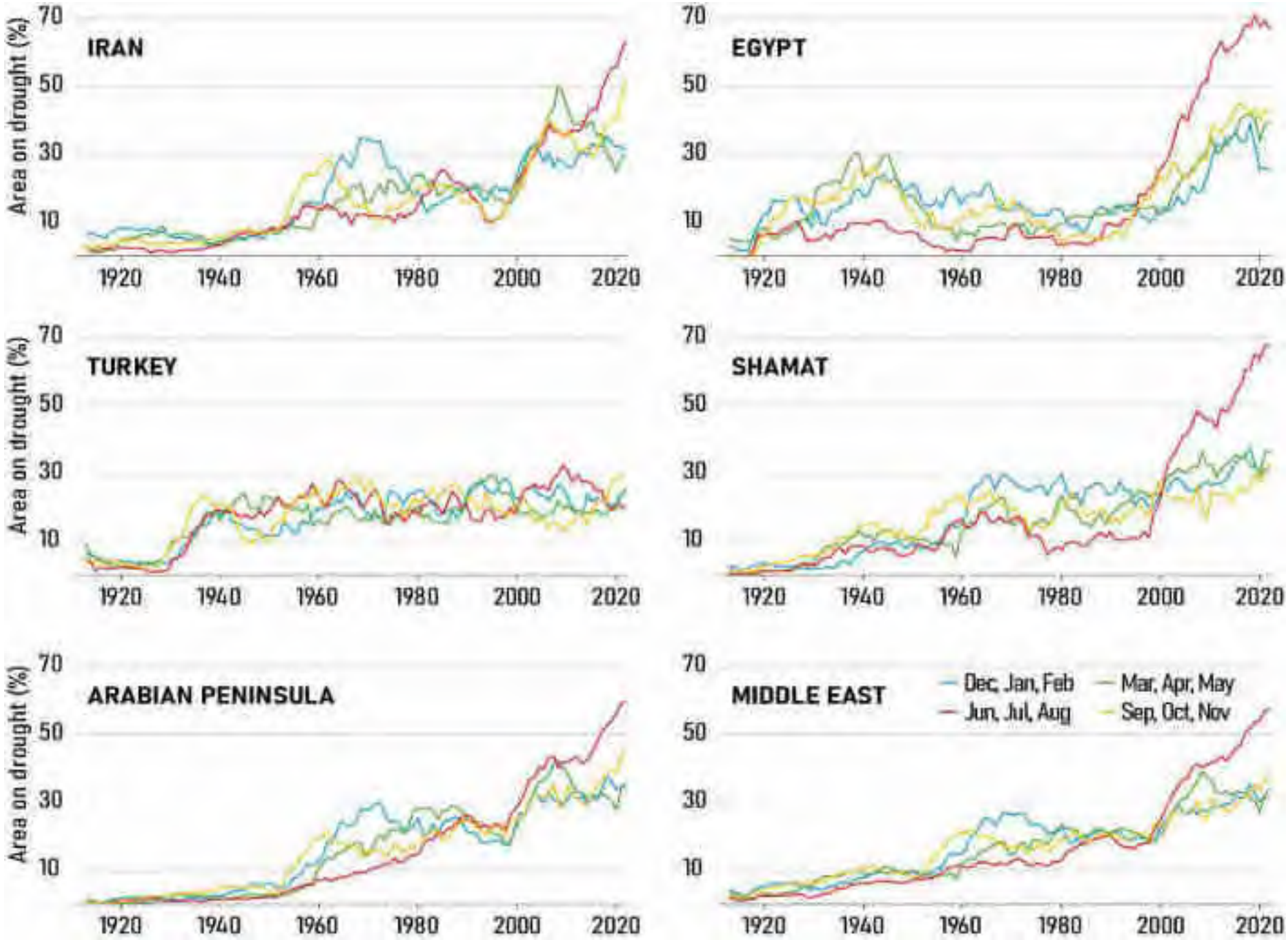
6.3 %

Climate change

The cause of the water crisis

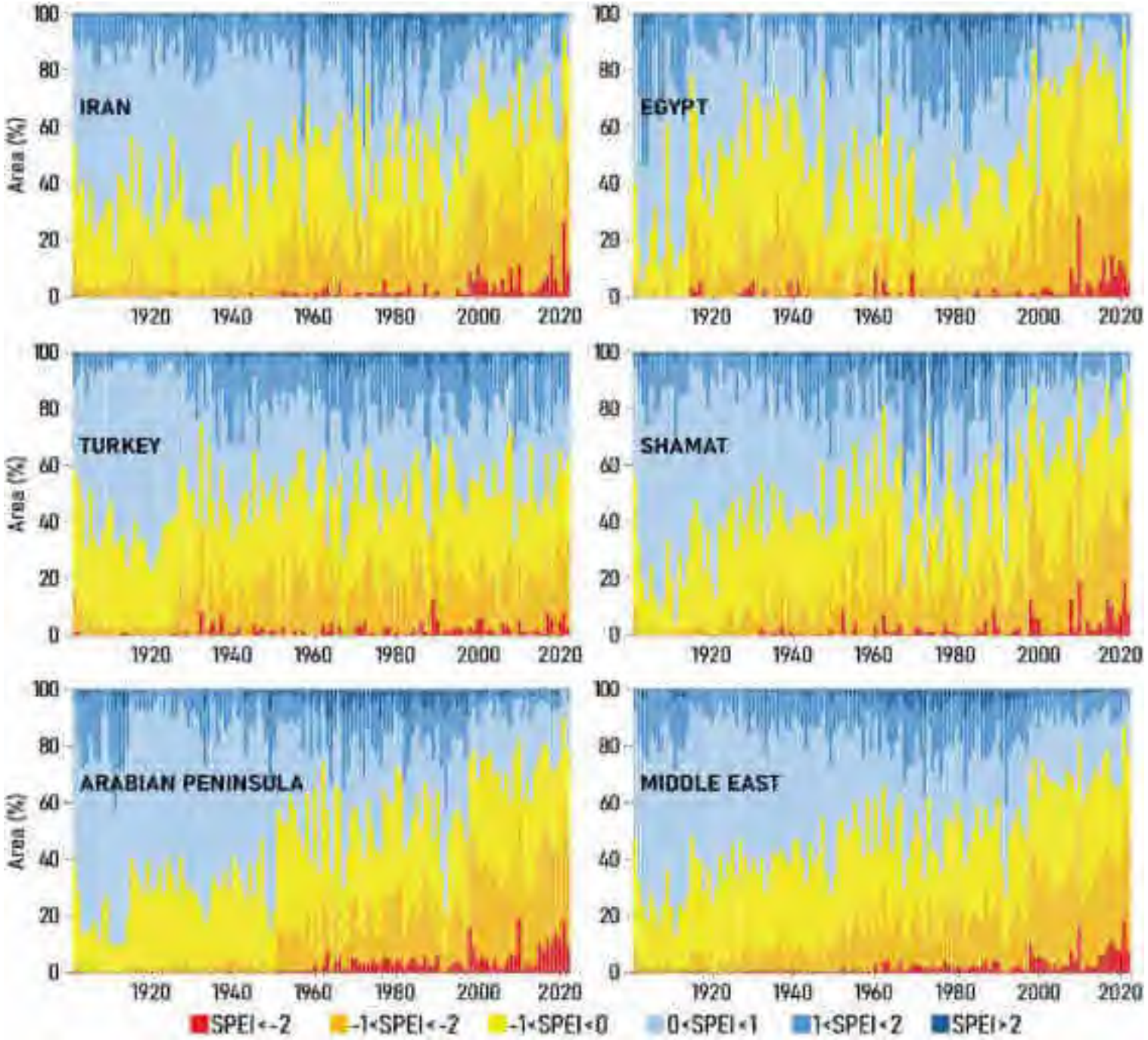


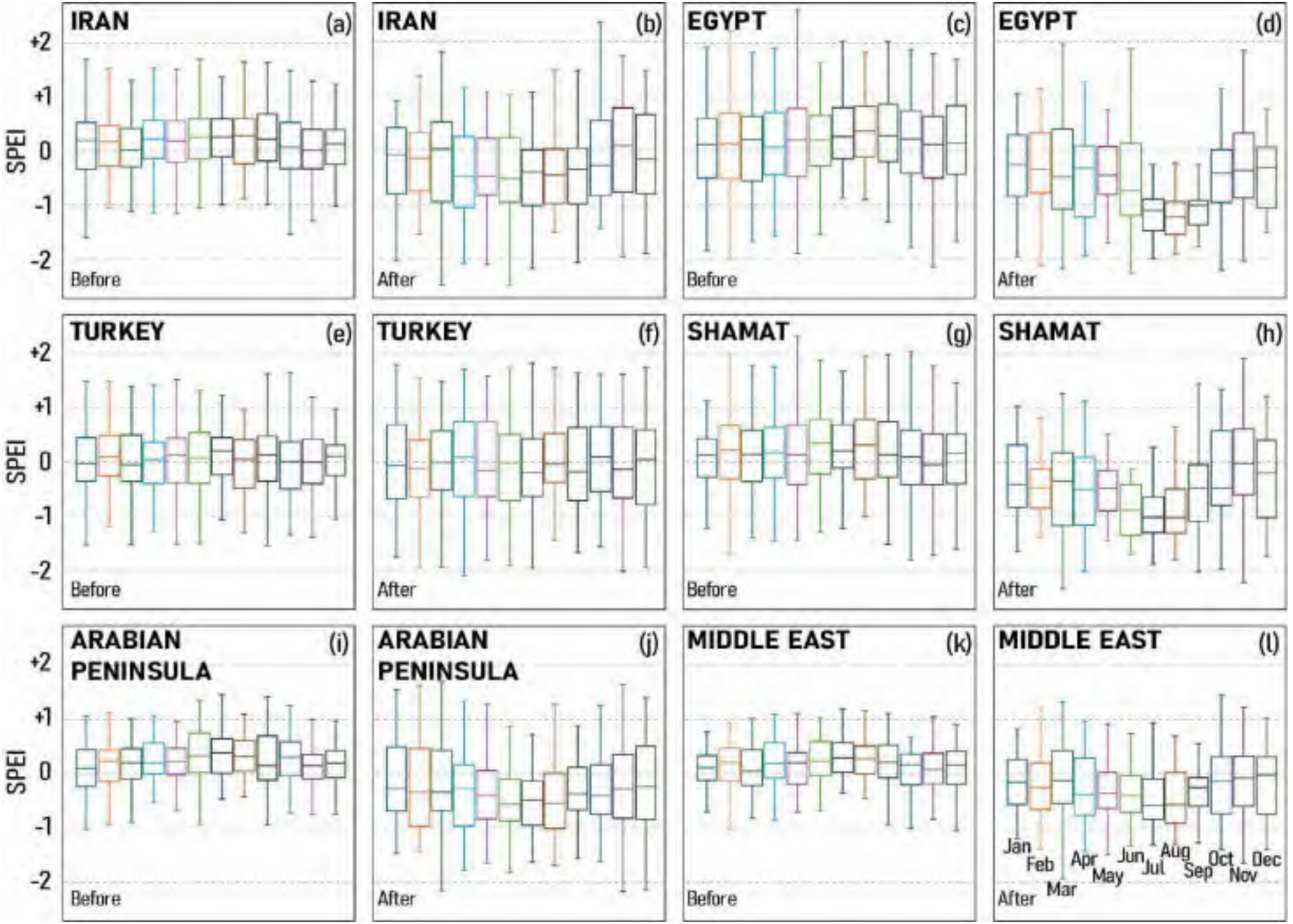
Climate change
DROUGHT


IRAN
EGYPT
TURKEY
SHAMAT
ARABIAN PENINSULA
MIDDLE EAST
Area on drought (%)
70
50
30
10
1920
1940
1960
1980
2000
2020
Dec, Jan, Feb
Mar, Apr, May
Jun, Jul, Aug
Sep, Oct, Nov

ECO

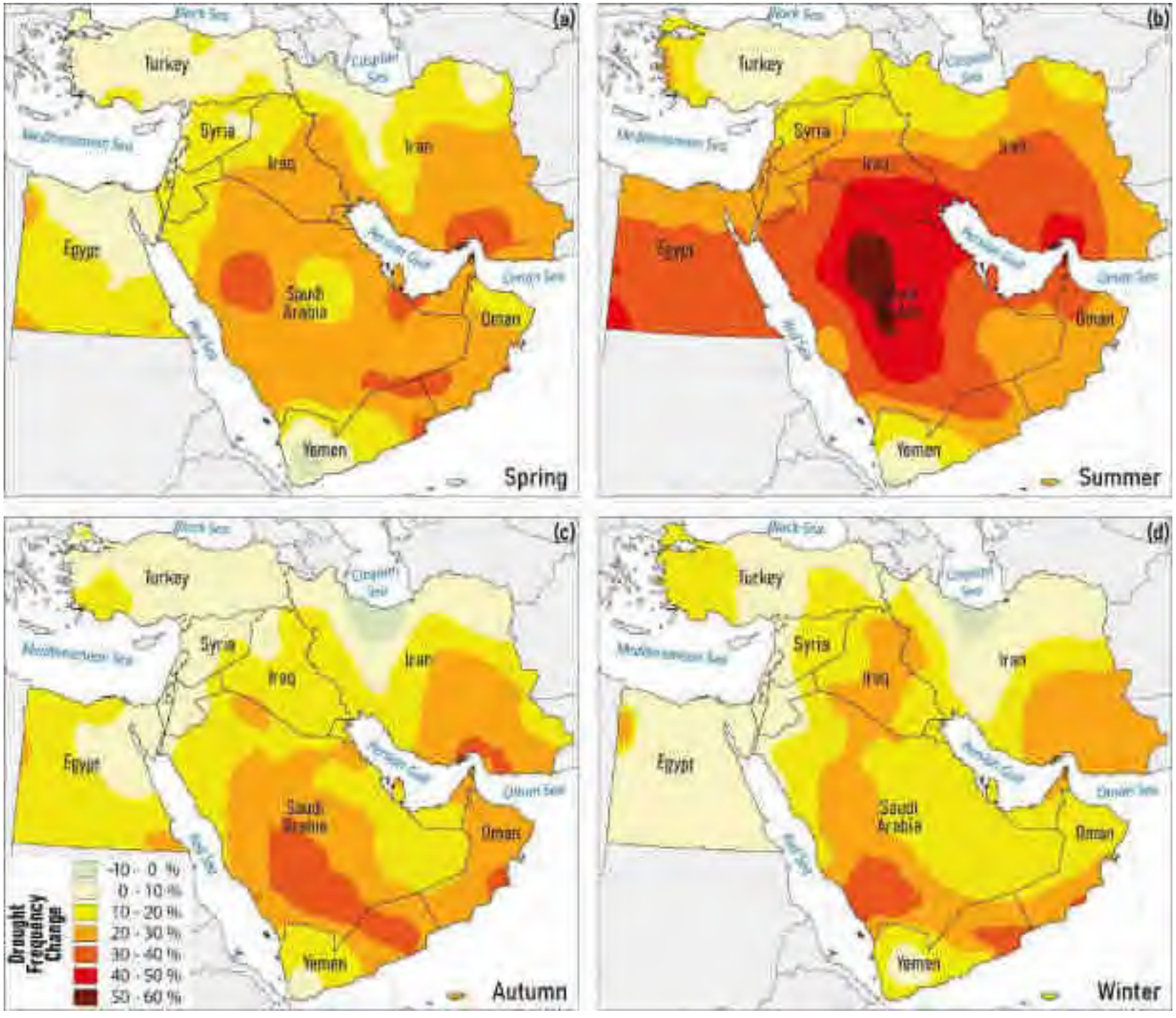
National Cartographic Center of IRAN

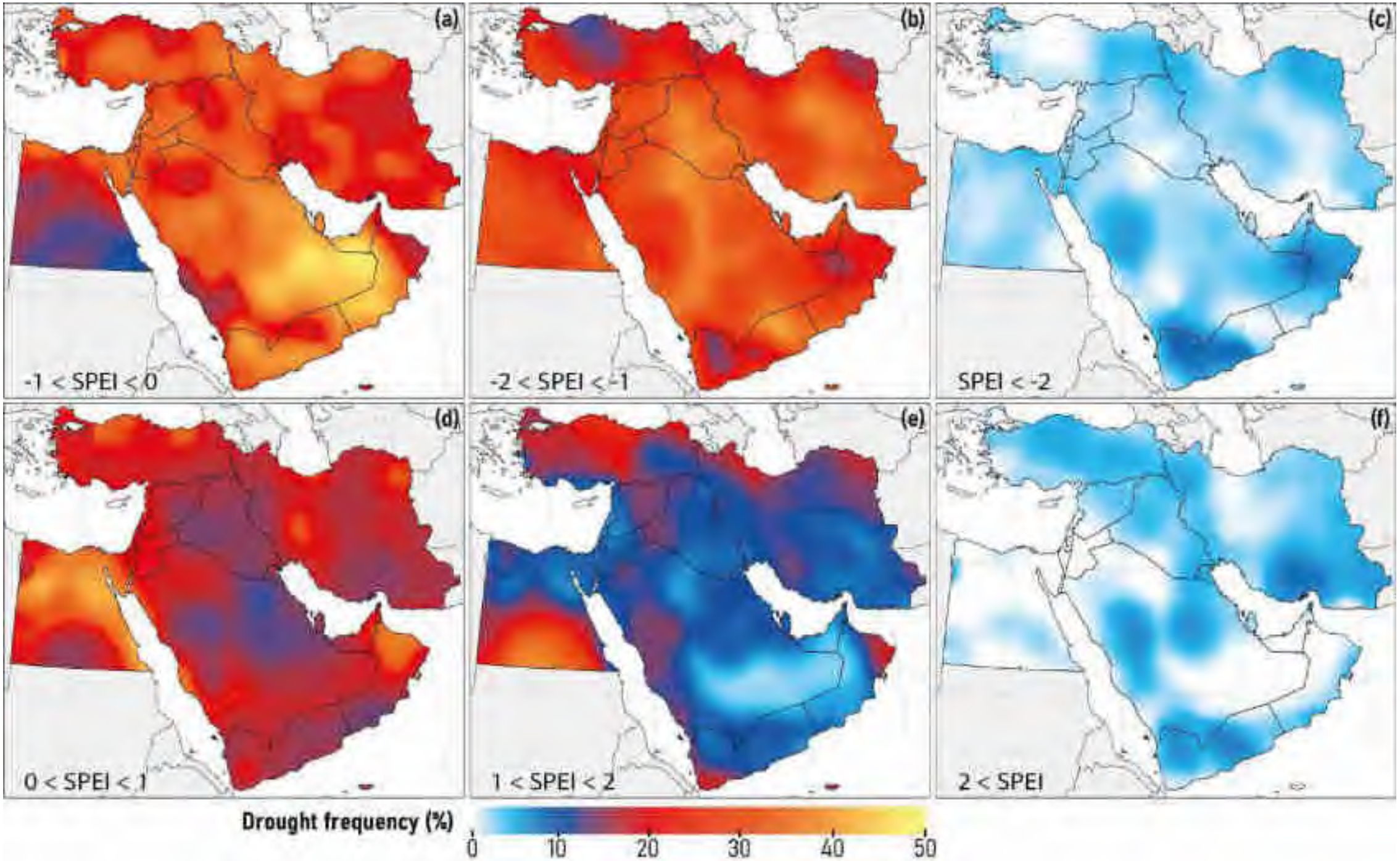


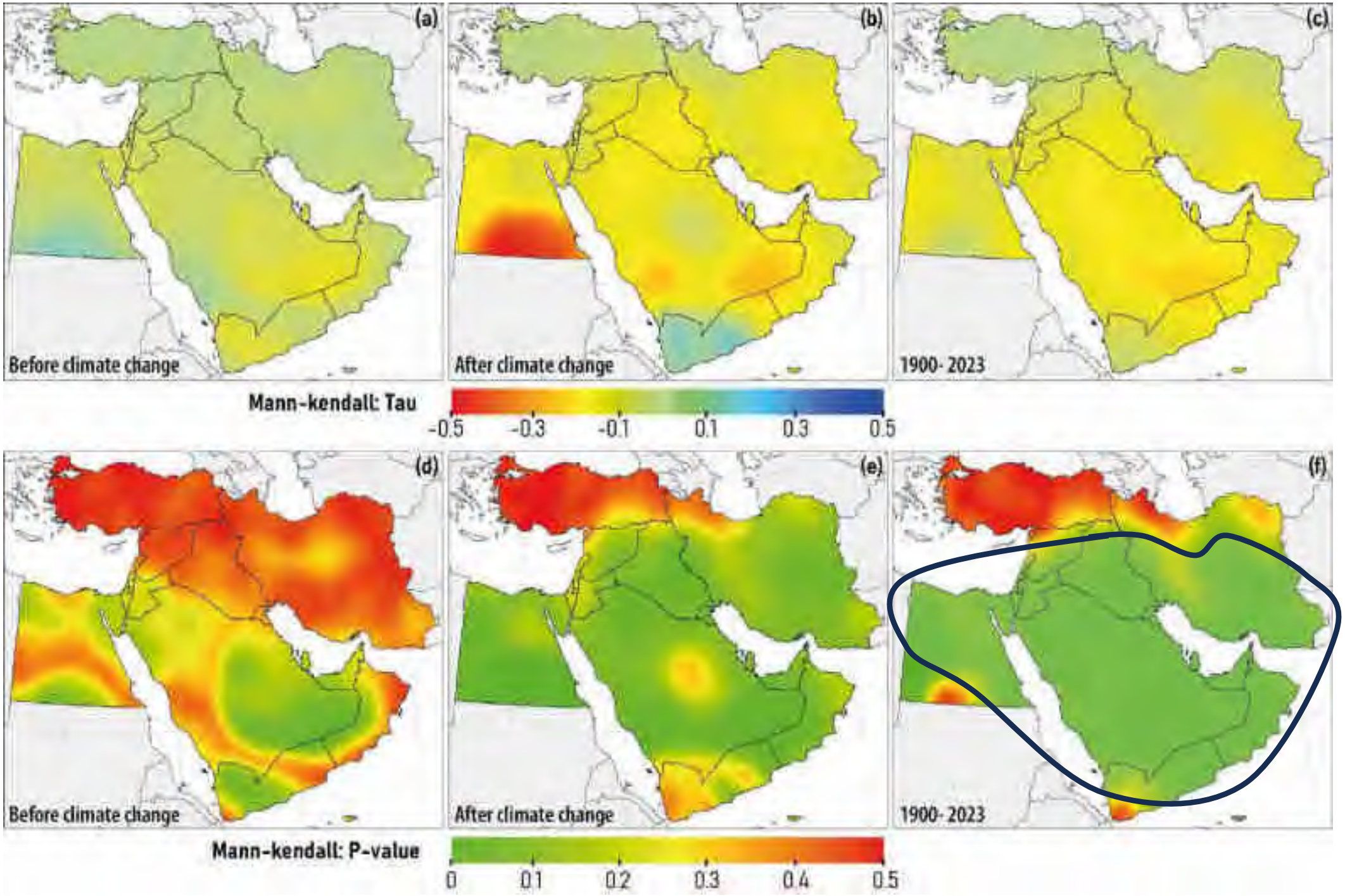

IRAN
(a)
Before
IRAN
(b)
After
EGYPT
(c)
Before
EGYPT
(d)
After
TURKEY
(e)
Before
TURKEY
(f)
After
SHAMAT
(g)
Before
SHAMAT
(h)
After
ARABIAN PENINSULA
(i)
Before
ARABIAN PENINSULA
(j)
After
MIDDLE EAST
(k)
Before
MIDDLE EAST
(l)
After
SPEI
+2
+1
0
-1
-2
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

ECO

National Cartographic Center of IRAN

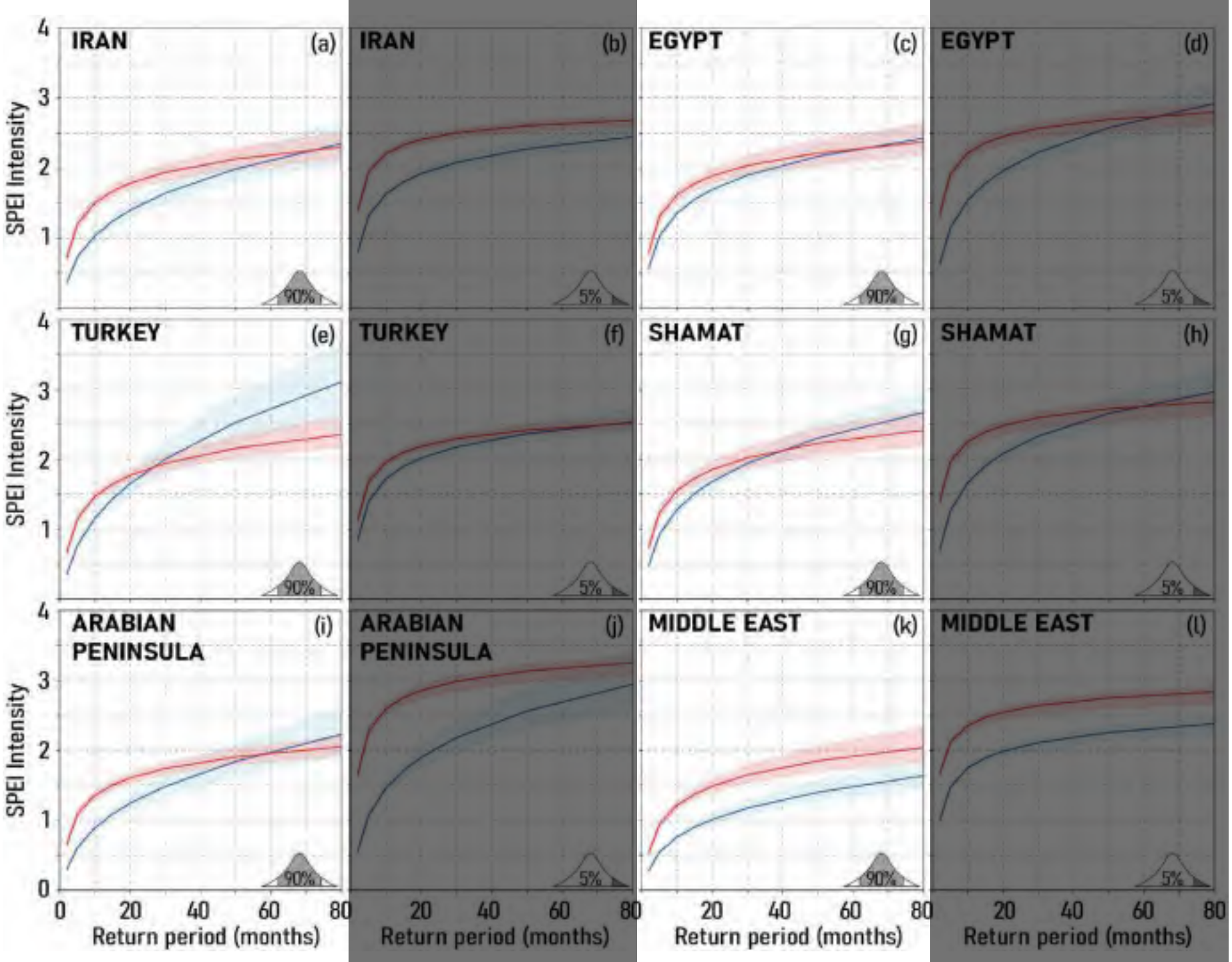



(a)
-1 < SPEI < 0
(b)
-2 < SPEI < -1
(c)
SPEI < -2
(d)
0 < SPEI < 1
(e)
1 < SPEI < 2
(f)
2 < SPEI
Drought frequency (%)
0
10
20
30
40
50


(a)
(b)
(c)
Before climate change
After climate change
1900- 2023
Mann-kendall: Tau
-0.5
-0.3
-0.1
0.1
0.3
0.5
(d)
(e)
(f)
Before climate change
After climate change
1900- 2023
Mann-kendall: P-value
0
0.1
0.2
0.3
0.4
0.5

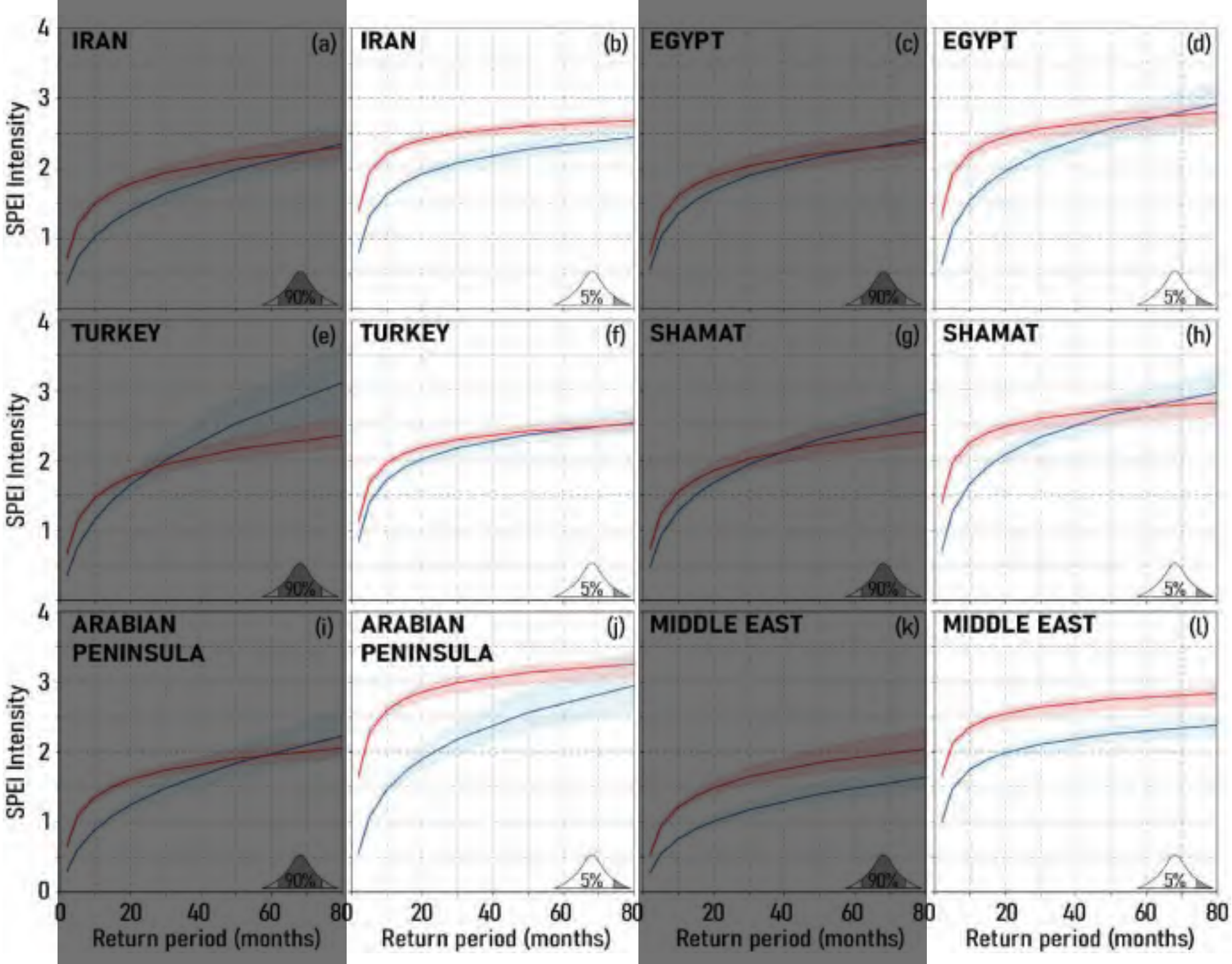
Red: After Climate change

Blue: Before Climate change



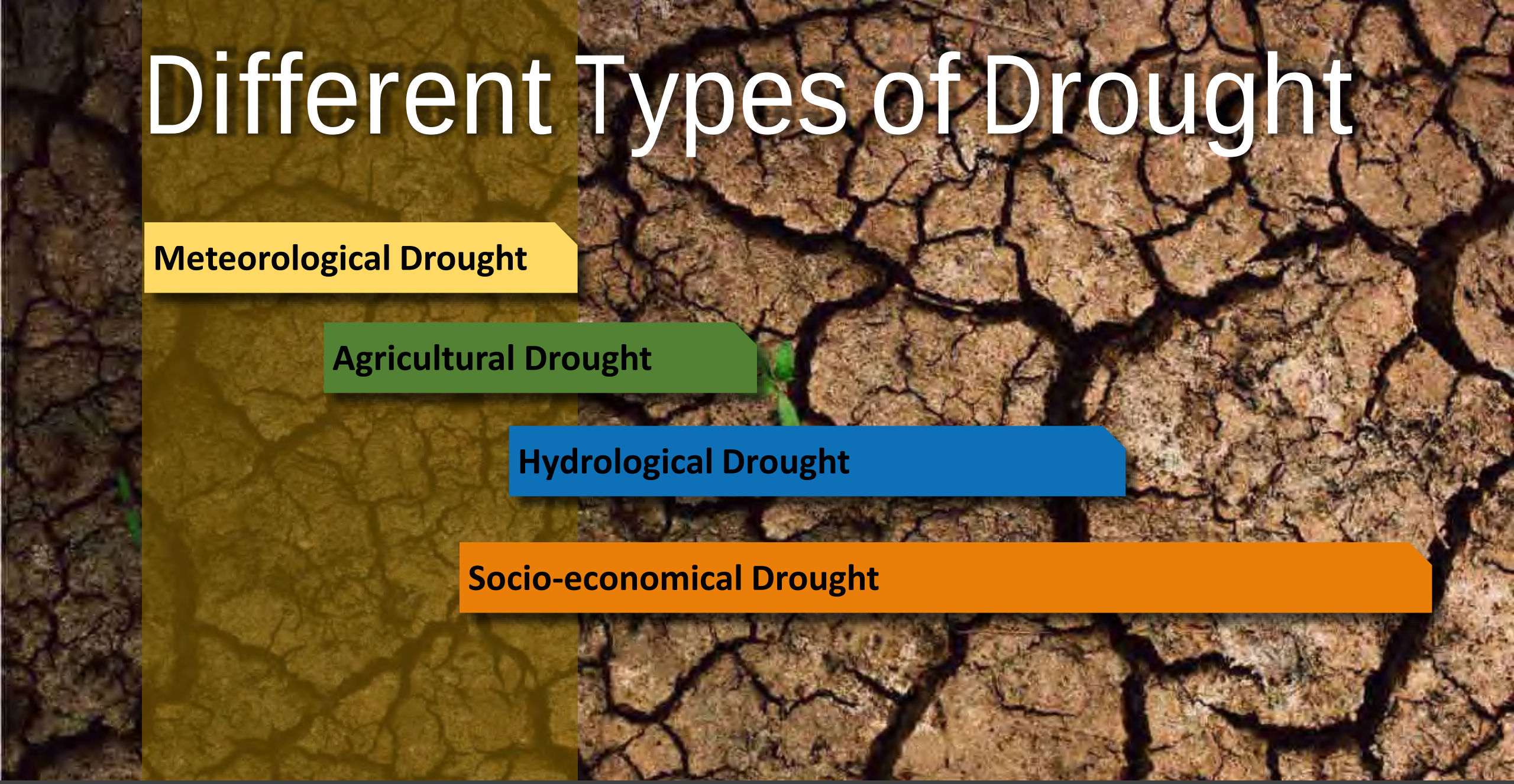
Red: After Climate change

Blue: Before Climate change



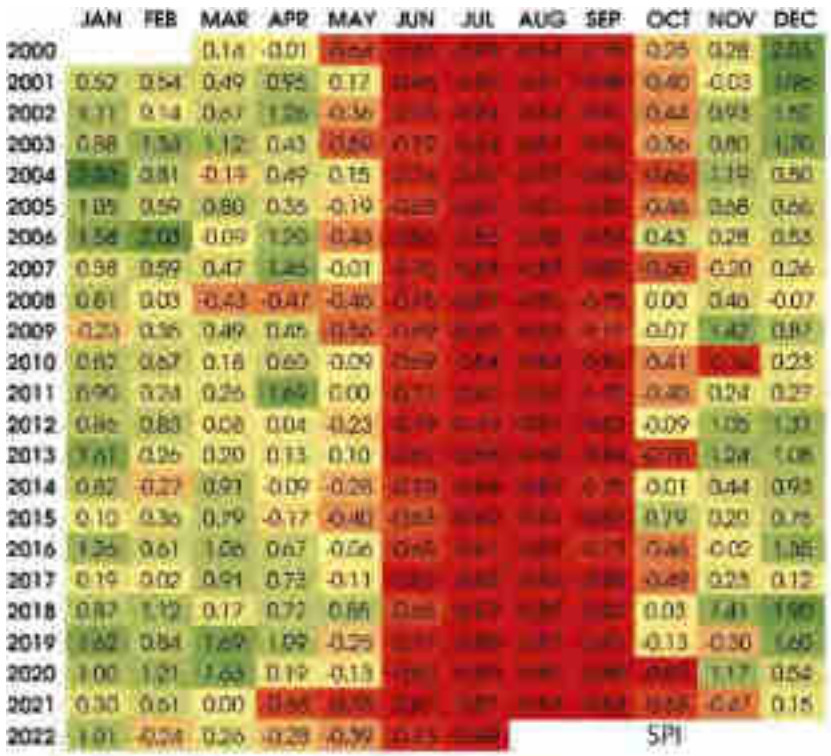
Different Types of Drought

- Meteorological Drought
- Agricultural Drought
- Hydrological Drought
- Socio-economical Drought

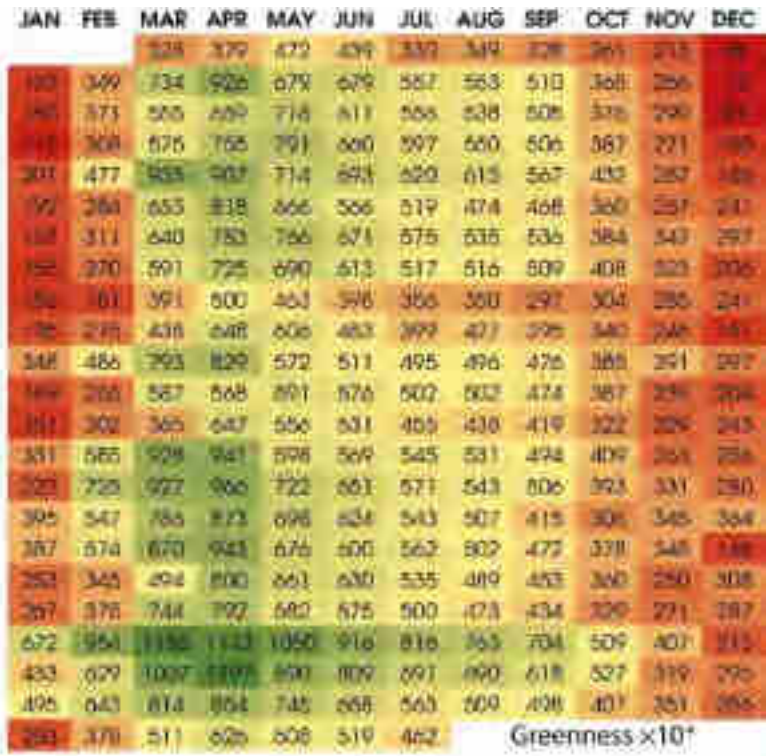


T I M E

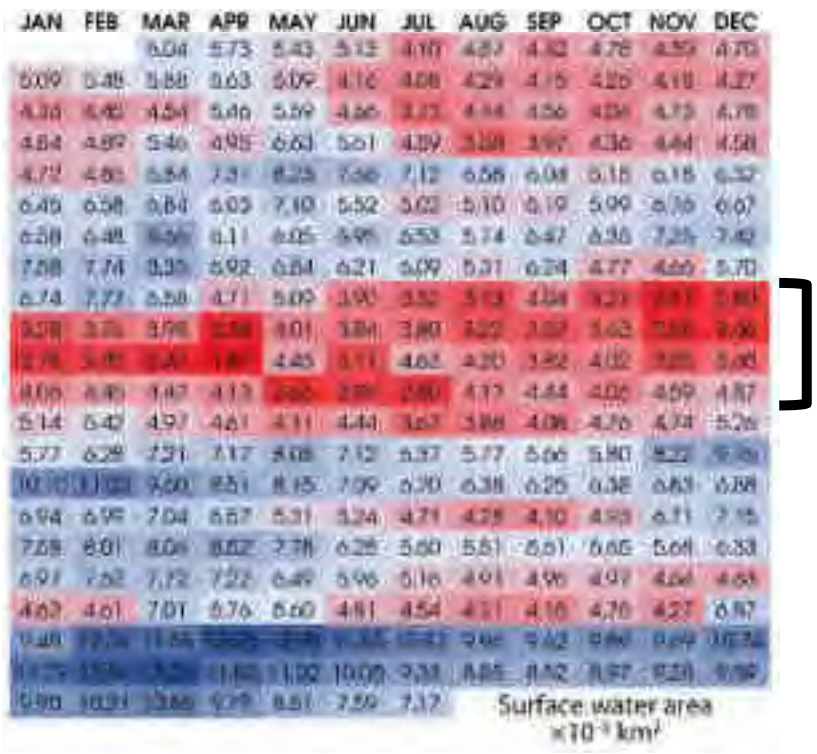
Meteorological Drought

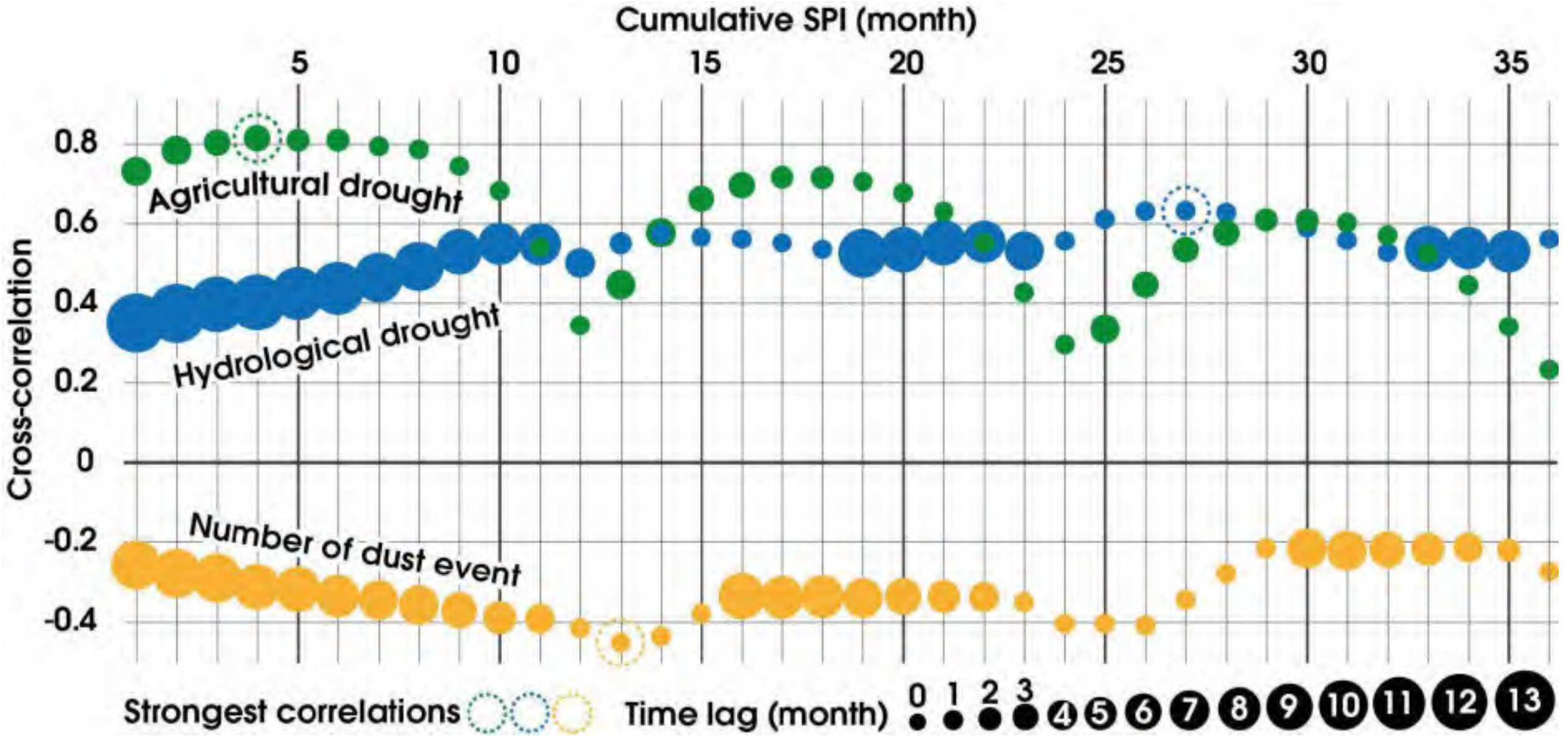


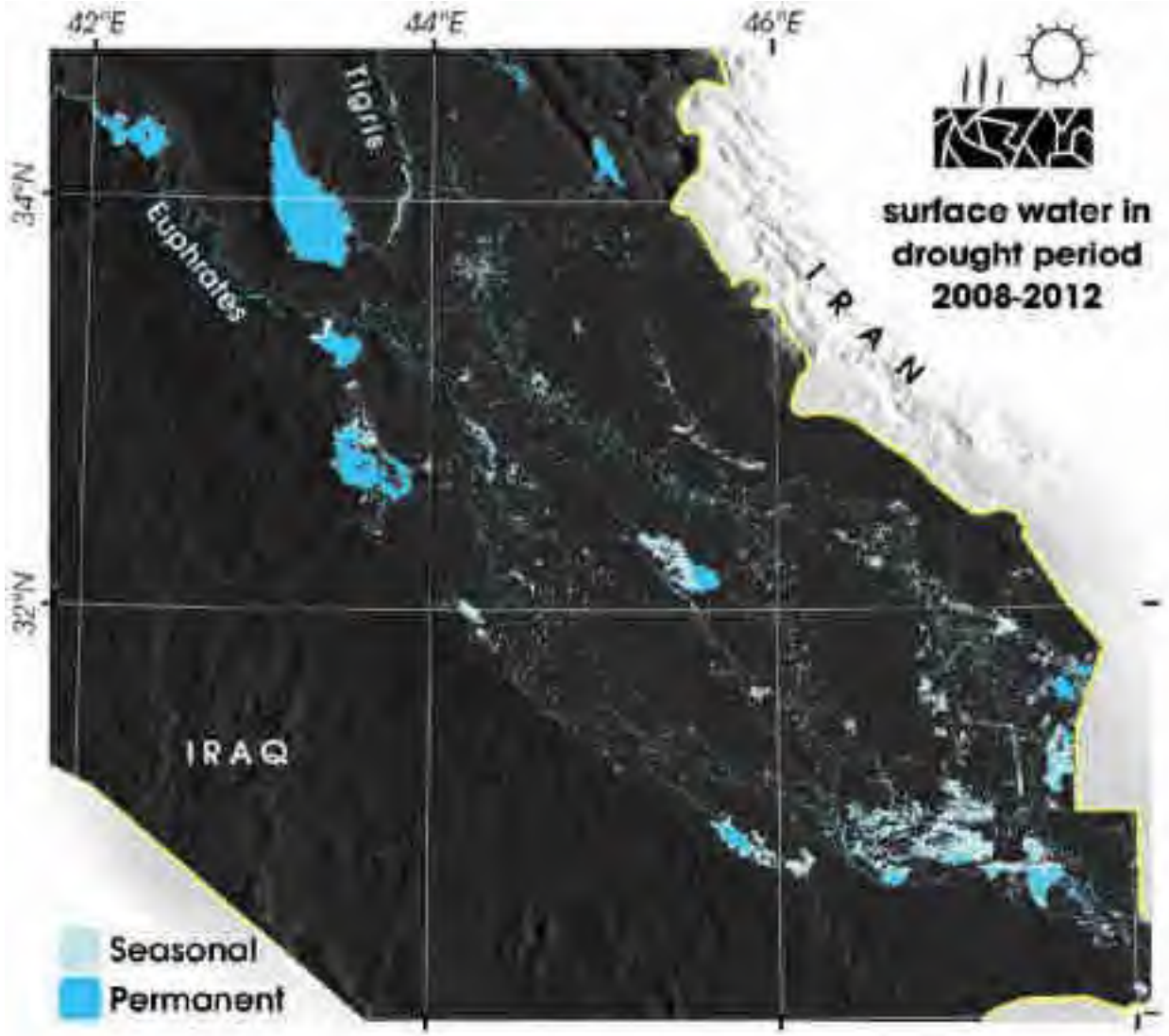
Agricultural Drought

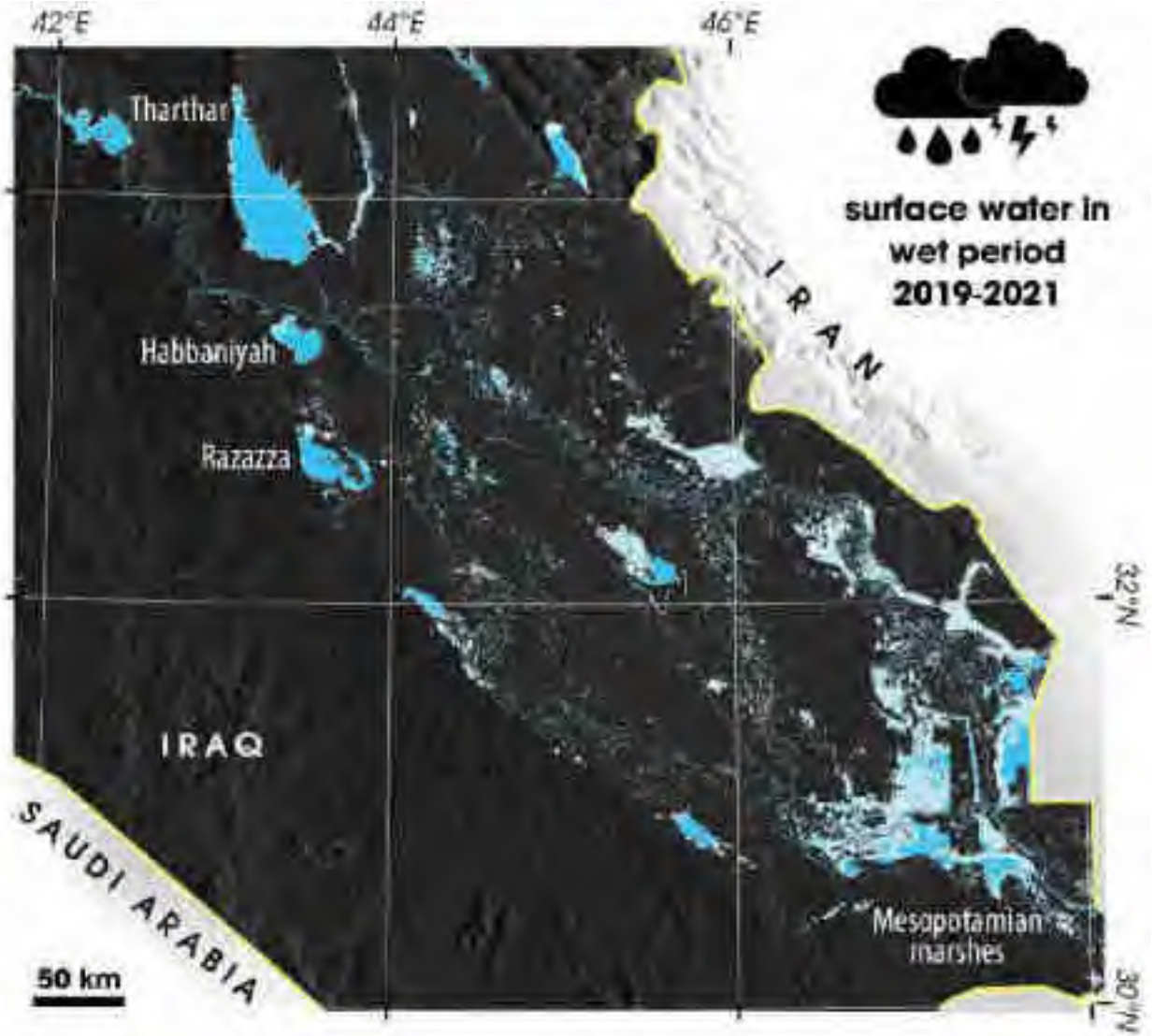


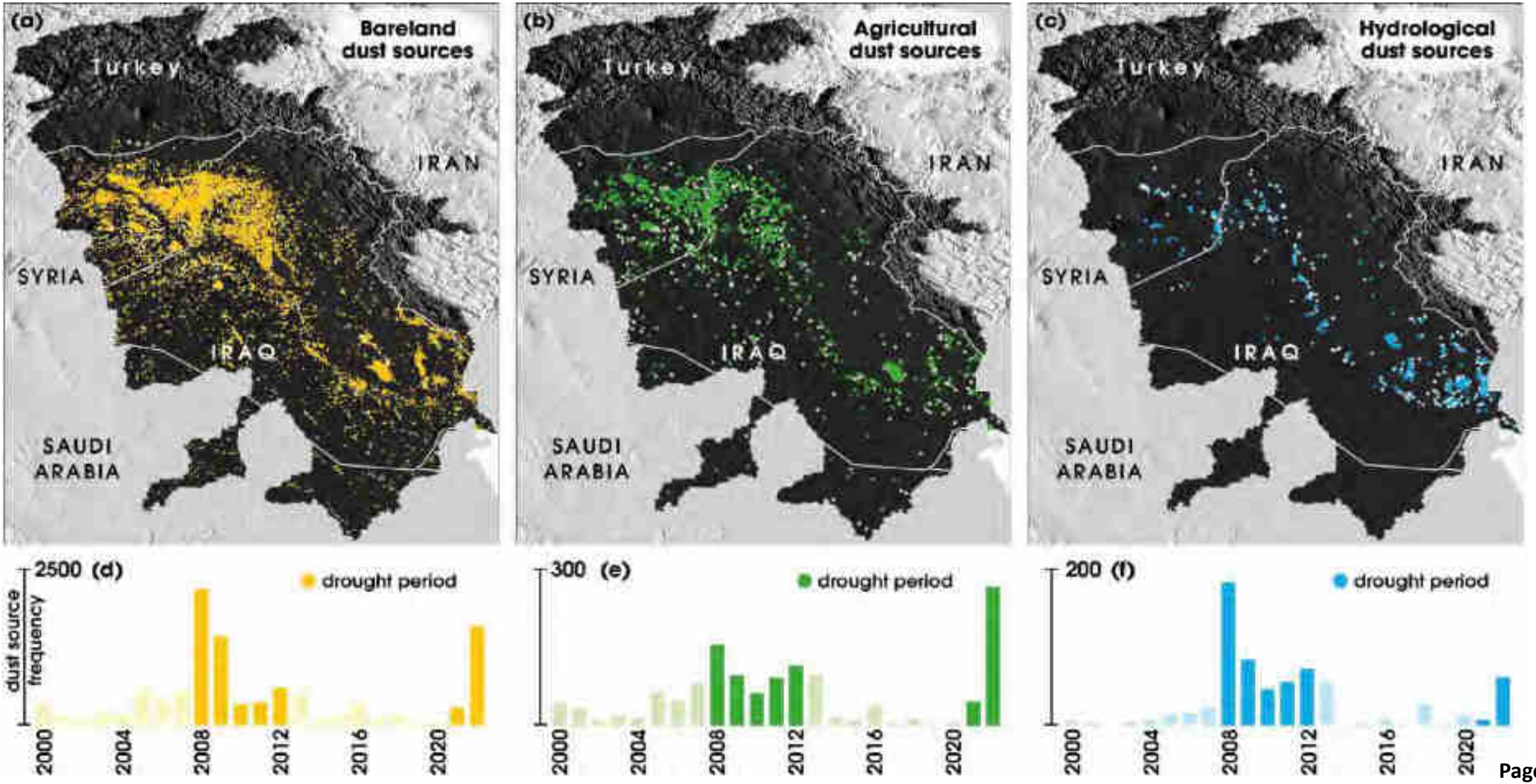
Hydrological Drought

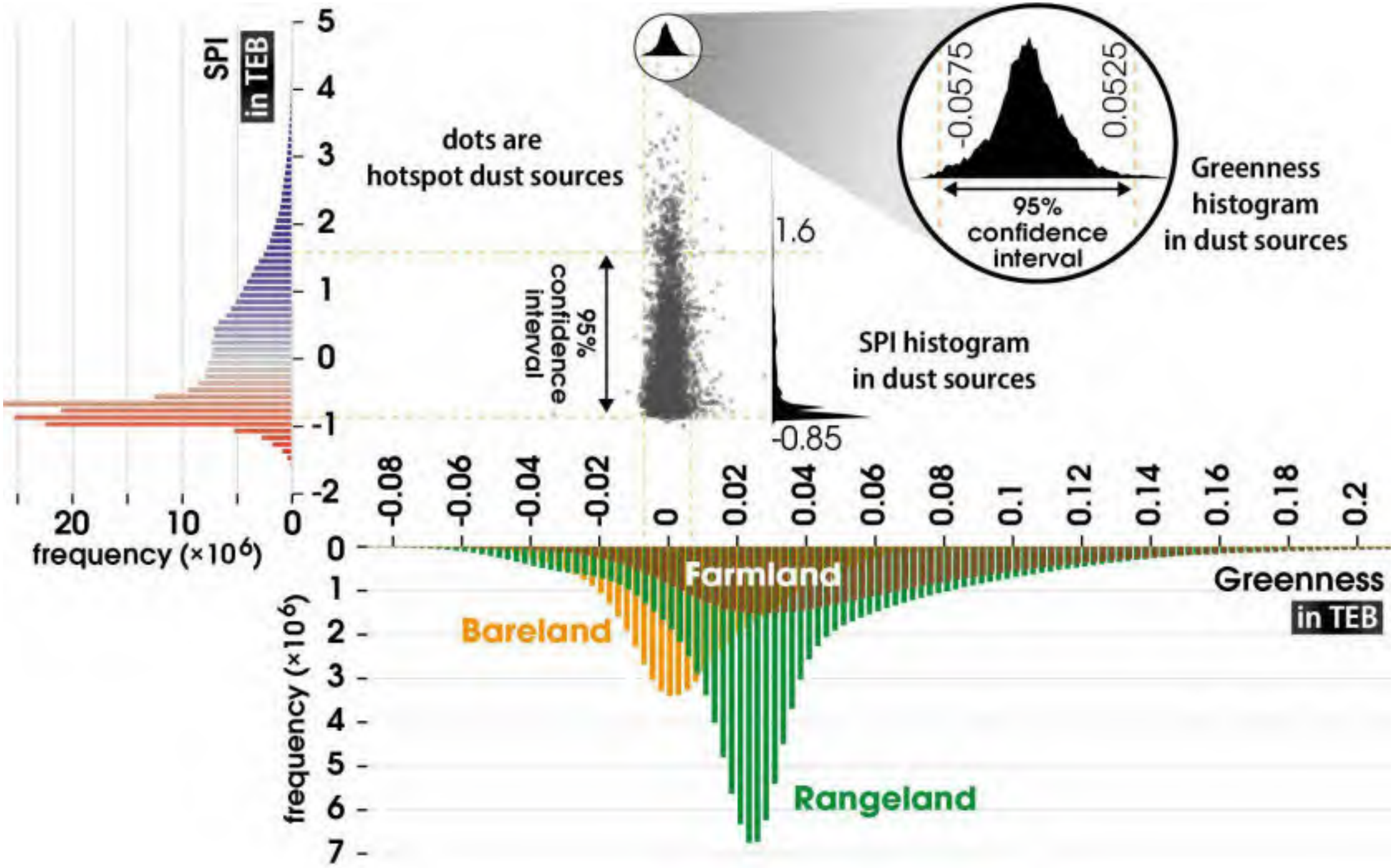



Cumulative SPI (month)
5
10
15
20
25
30
35
0.8
0.6
0.4
0.2
0
-0.2
-0.4
Cross-correlation
Agricultural drought
Hydrological drought
Number of dust event
Strongest correlations
Time lag (month)
0 1 2 3 4 5 6 7 8 9 10 11 12 13


42°E
44°E
46°E
34°N
32°N
Tigris
Euphrates
IRAN
IRAQ
surface water in
drought period
2008-2012
Seasonal
Permanent


42°E
44°E
46°E
32°N
30°N
Tharthar
Habbaniyah
Razazza
IRAN
IRAQ
SAUDI ARABIA
Mesopotamian marshes
50 km
surface water in
wet period
2019-2021

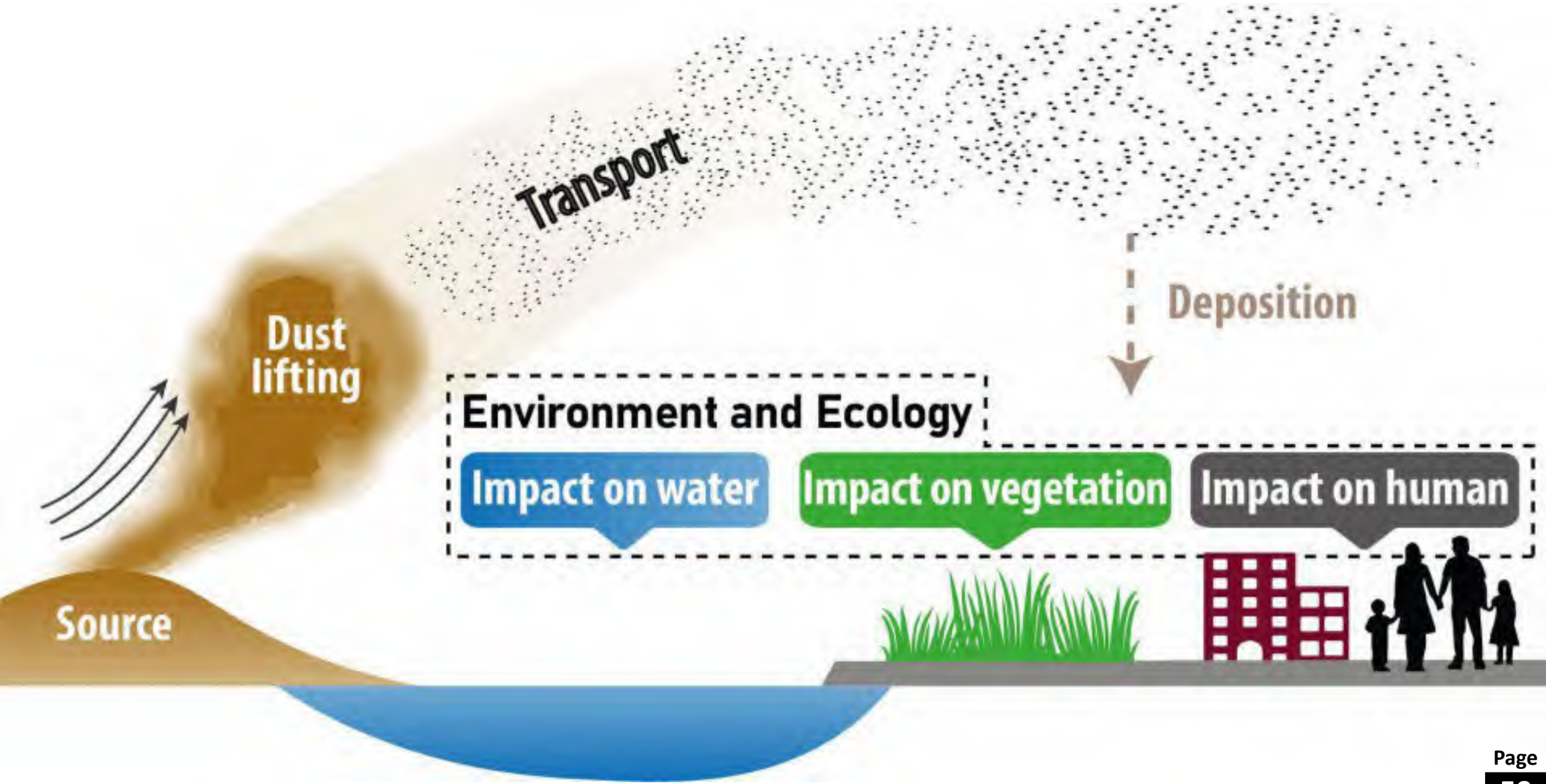

(a)
Bareland dust sources
Turkey
IRAN
SYRIA
IRAQ
SAUDI ARABIA
(b)
Agricultural dust sources
Turkey
IRAN
SYRIA
IRAQ
SAUDI ARABIA
(c)
Hydrological dust sources
Turkey
IRAN
SYRIA
IRAQ
SAUDI ARABIA
2500 (d)
drought period
dust source frequency
2000
2004
2008
2012
2016
2020
300 (e)
drought period
2000
2004
2008
2012
2016
2020
200 (f)
drought period
2000
2004
2008
2012
2016
2020


SPI in TEB
5
4
3
2
1
0
-1
-2
20
10
0
frequency (×10⁶)
dots are hotspot dust sources
95% confidence interval
1.6
-0.85
SPI histogram in dust sources
-0.0575
0.0525
95% confidence interval
Greenness histogram in dust sources
-0.08
-0.06
-0.04
-0.02
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
Greenness in TEB
Farmland
Bareland
Rangeland
frequency (×10⁶)
0
1
2
3
4
5
6
7

Climate change

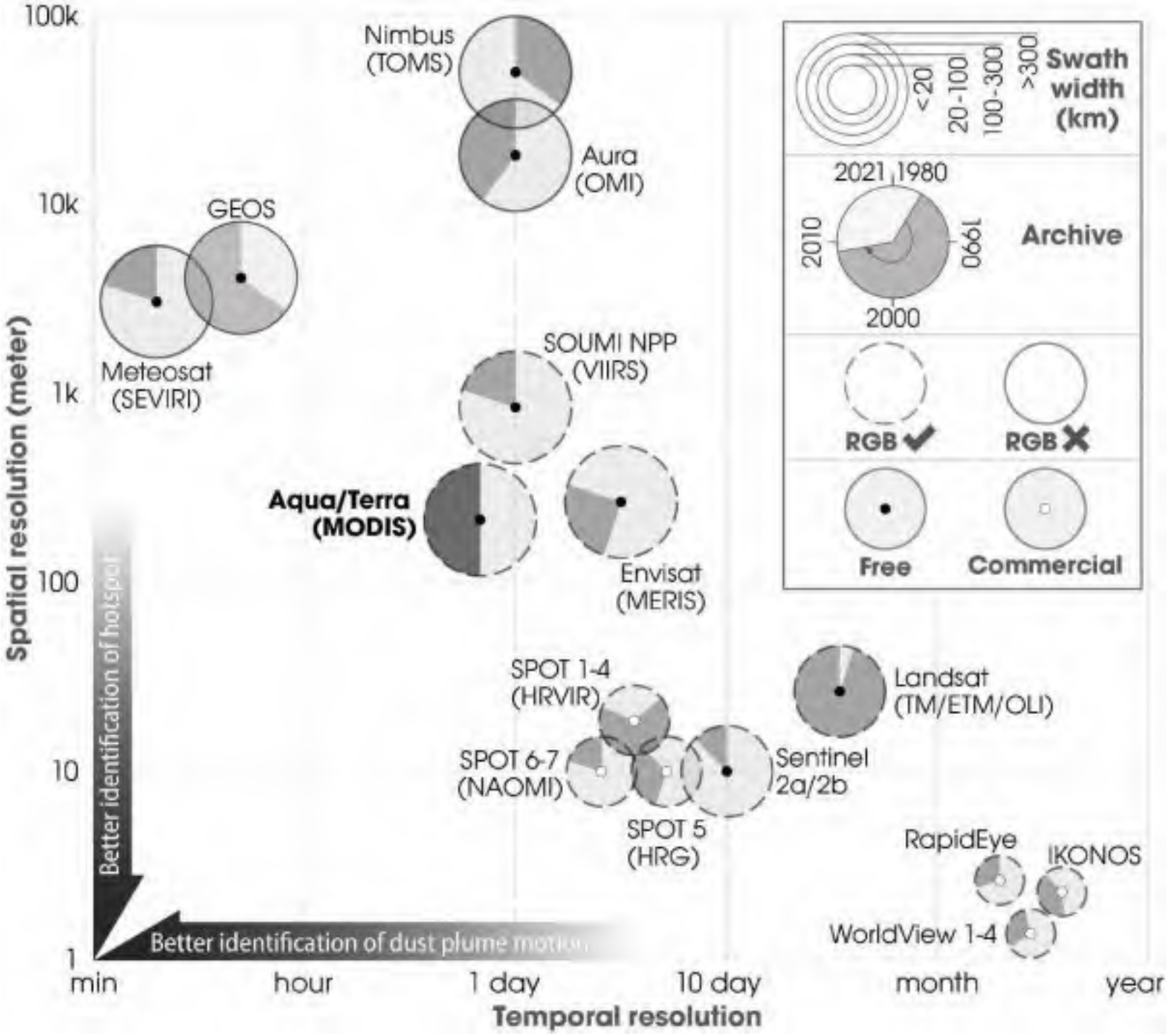
DUST

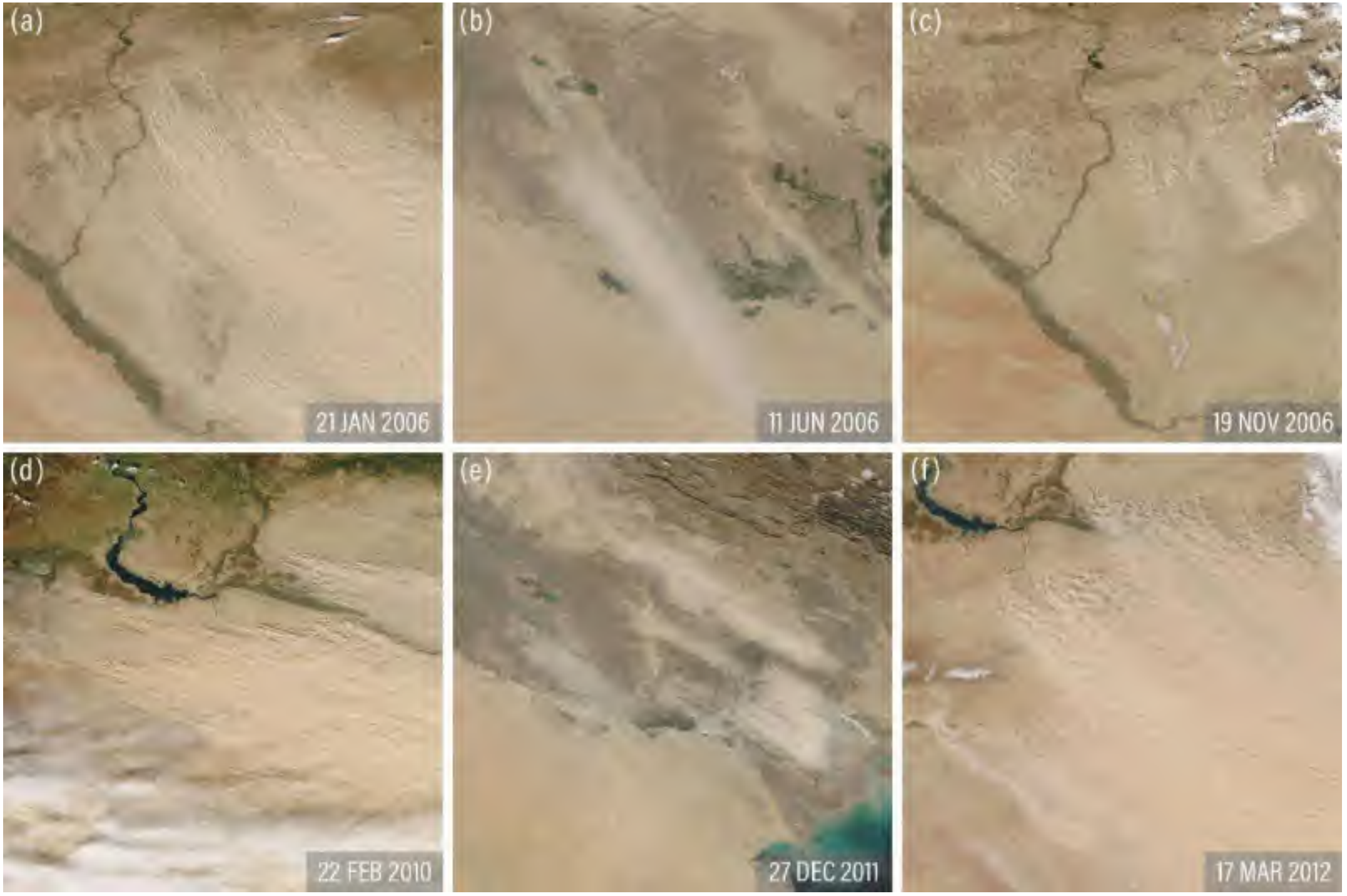
Sand & dust storms drivers
Land cover
Vegetation type
Vegetation density
Climate
Precipitation
Drought
Wind
Temperature
Socio economic
Agriculture
Water control/usage
Land use
Soil
Texture
Moisture
Organic matter

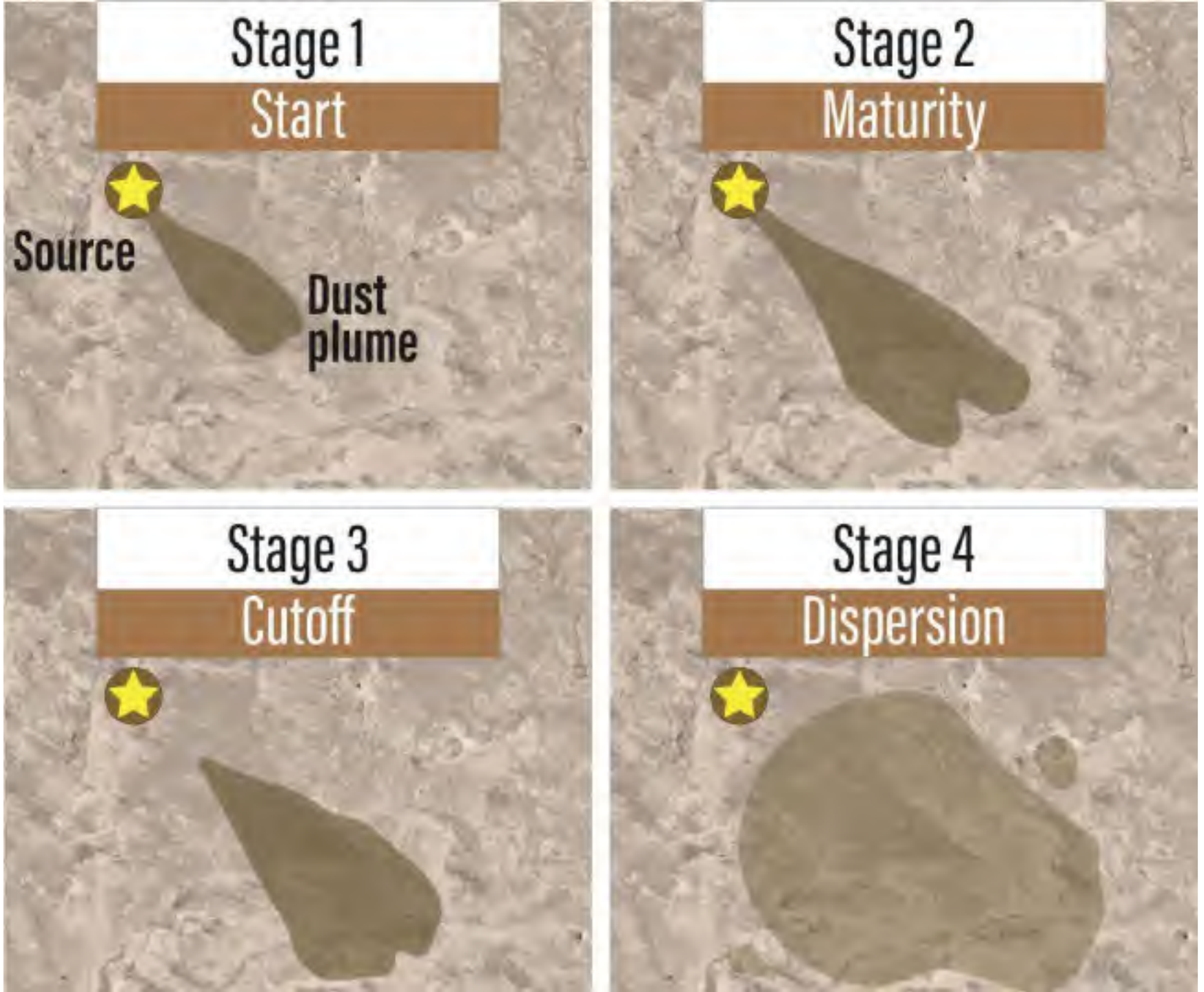

Transport
Deposition
Dust lifting
Environment and Ecology
Impact on water
Impact on vegetation
Impact on human
Source

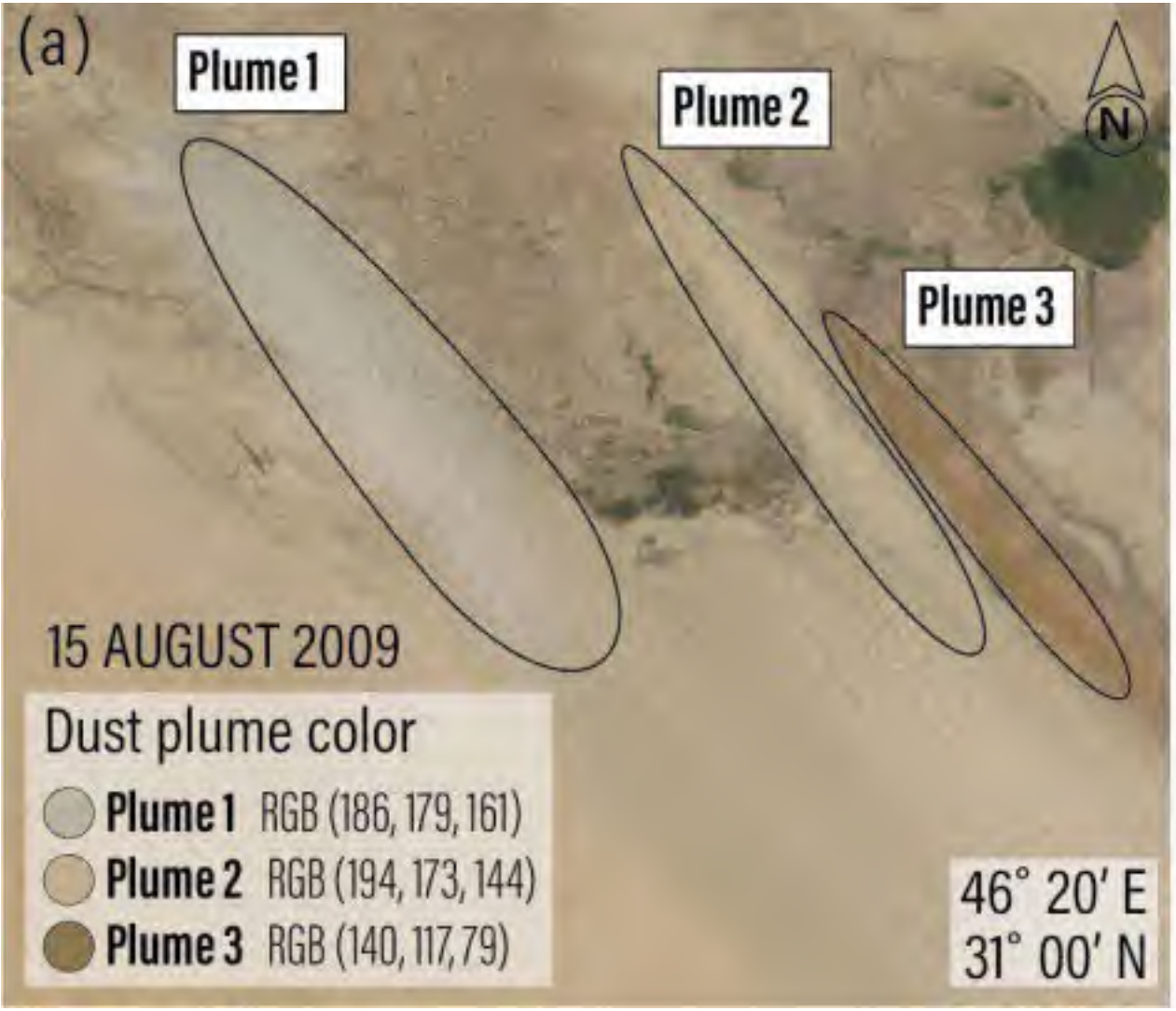
ECO

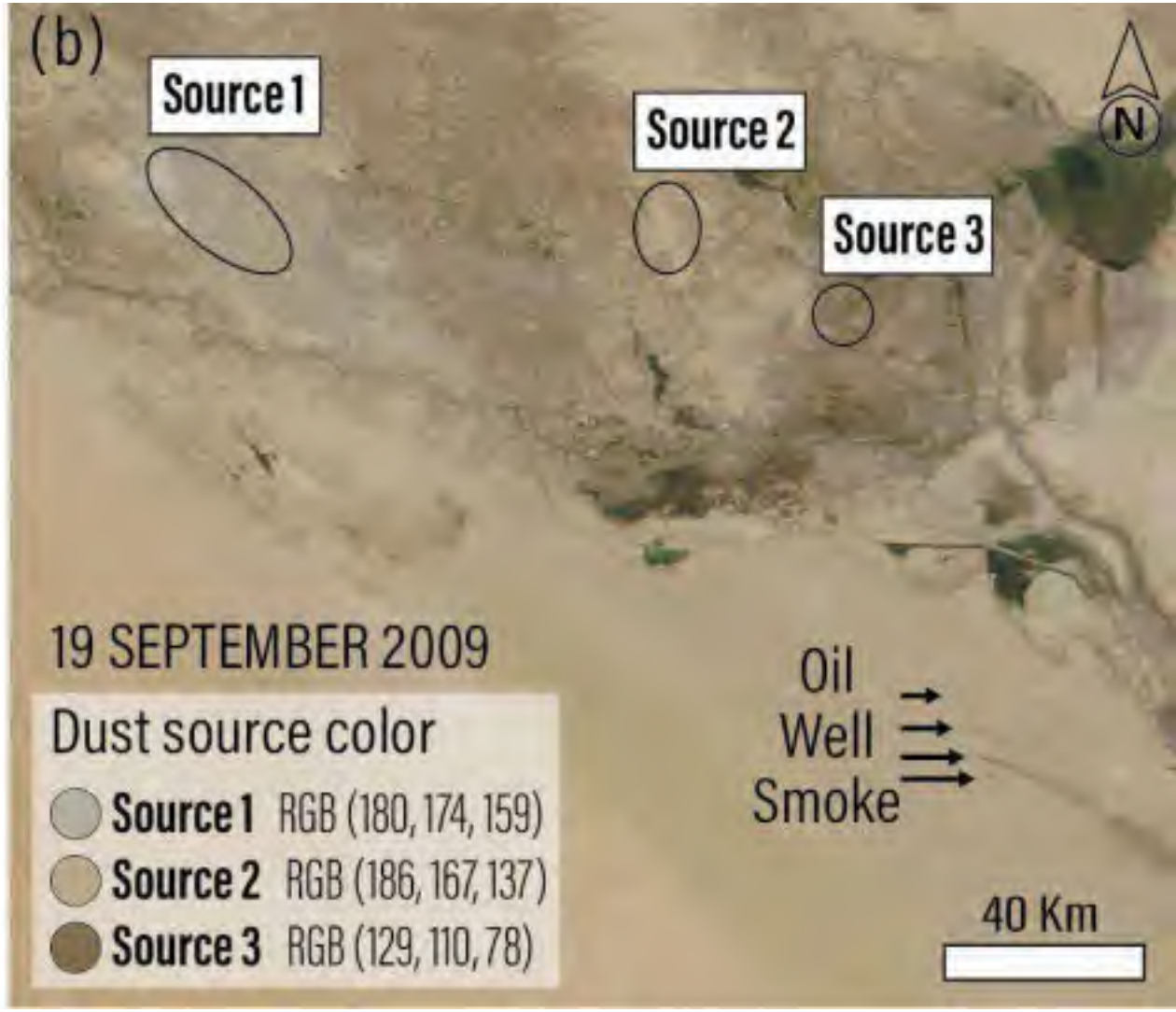
National Cartographic Center of IRAN


100k
10k
1k
100
10
1
Spatial resolution (meter)
Nimbus (TOMS)
Aura (OMI)
GEOS
Meteosat (SEVIRI)
SOUMI NPP (VIIRS)
Aqua/Terra (MODIS)
Envisat (MERIS)
SPOT 1-4 (HRVIR)
SPOT 6-7 (NAOMI)
SPOT 5 (HRG)
Landsat (TM/ETM/OLI)
Sentinel 2a/2b
RapidEye
IKONOS
WorldView 1-4
Better identification of hotspot
Better identification of dust plume motion
min
hour
1 day
10 day
month
year
Temporal resolution
<20
20-100
100-300
>300
Swath width (km)
2021
1980
2010
1990
2000
Archive
RGB
RGB
Free
Commercial

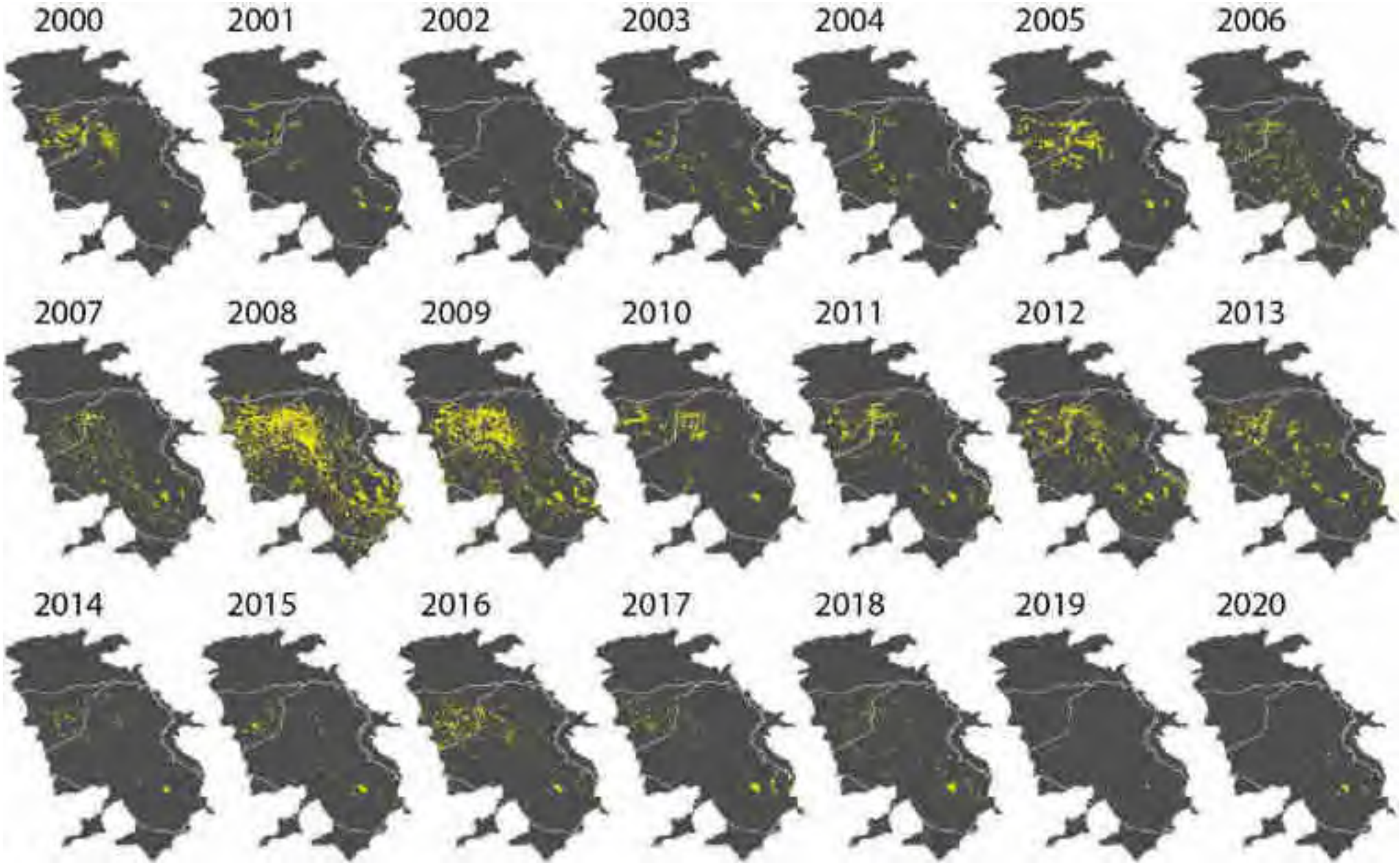

(a)
21 JAN 2006
(b)
11 JUN 2006
(c)
19 NOV 2006
(d)
22 FEB 2010
(e)
27 DEC 2011
(f)
17 MAR 2012


Stage 1
Start
Source
Dust plume
Stage 2
Maturity
Stage 3
Cutoff
Stage 4
Dispersion

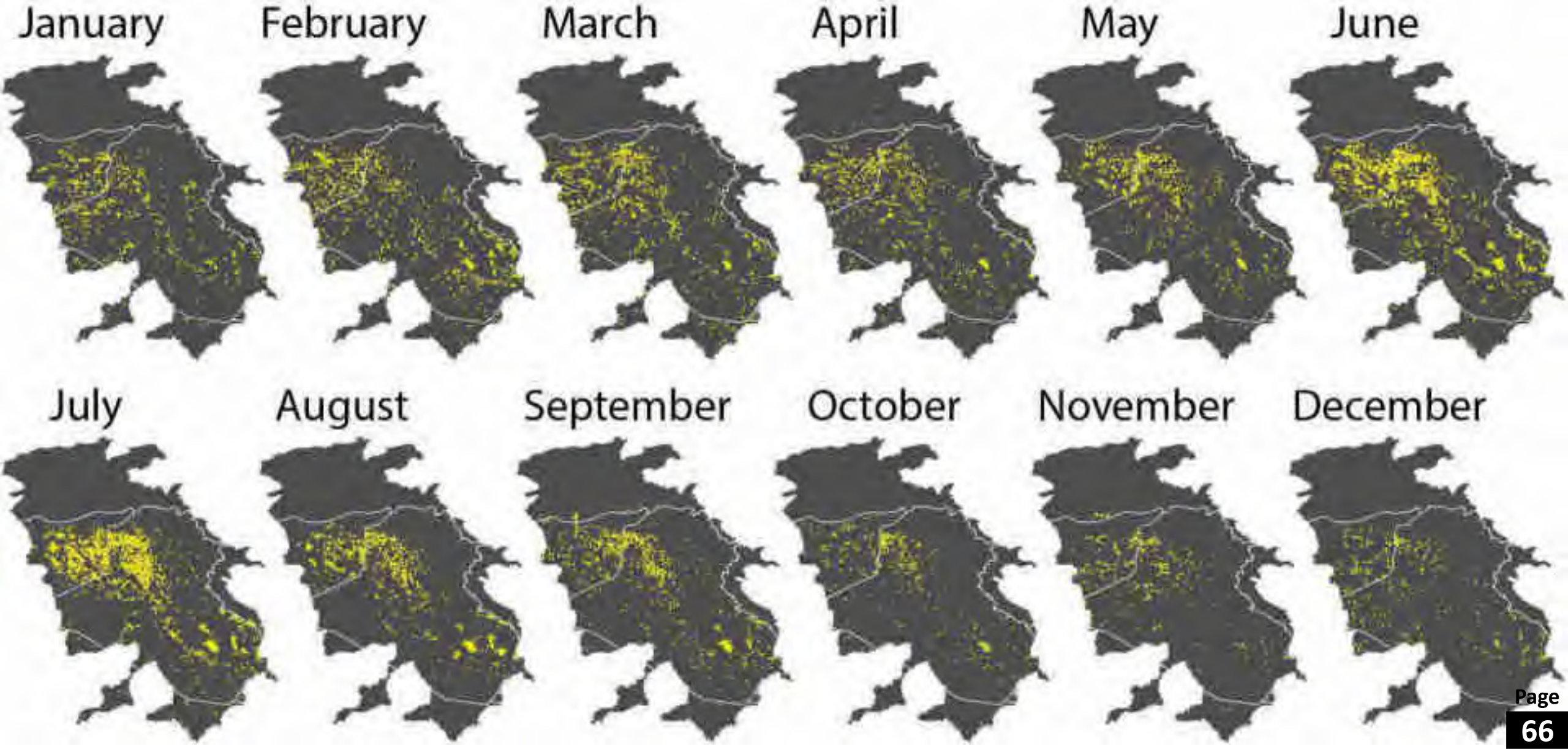

(a)
Plume 1
Plume 2
Plume 3
N
15 AUGUST 2009
Dust plume color
Plume 1 RGB (186, 179, 161)
Plume 2 RGB (194, 173, 144)
Plume 3 RGB (140, 117, 79)
46° 20′ E
31° 00′ N

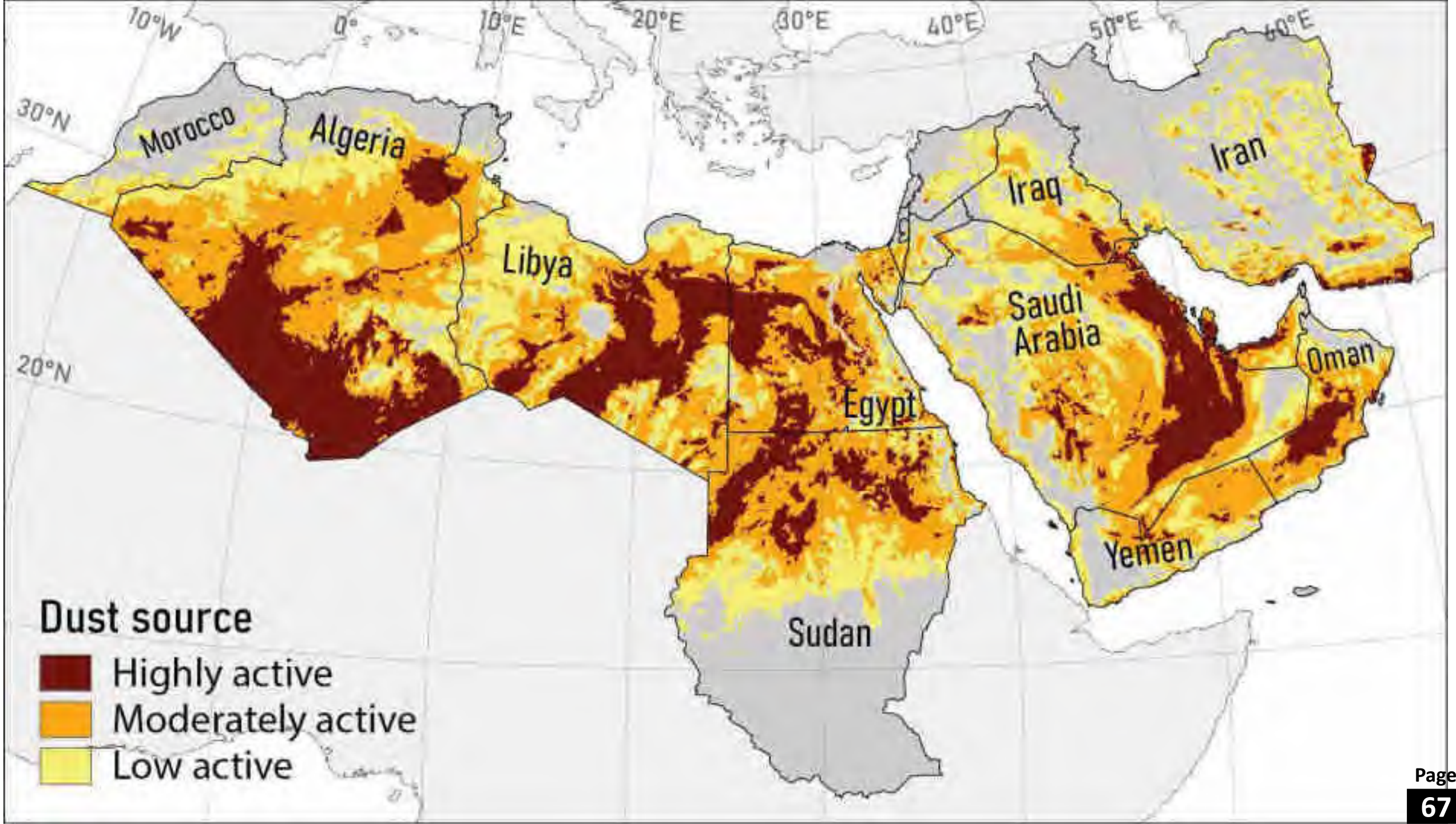

(b)
Source 1
Source 2
Source 3
N
19 SEPTEMBER 2009
Dust source color
Source 1 RGB (180, 174, 159)
Source 2 RGB (186, 167, 137)
Source 3 RGB (129, 110, 78)
Oil Well
Smoke
40 Km

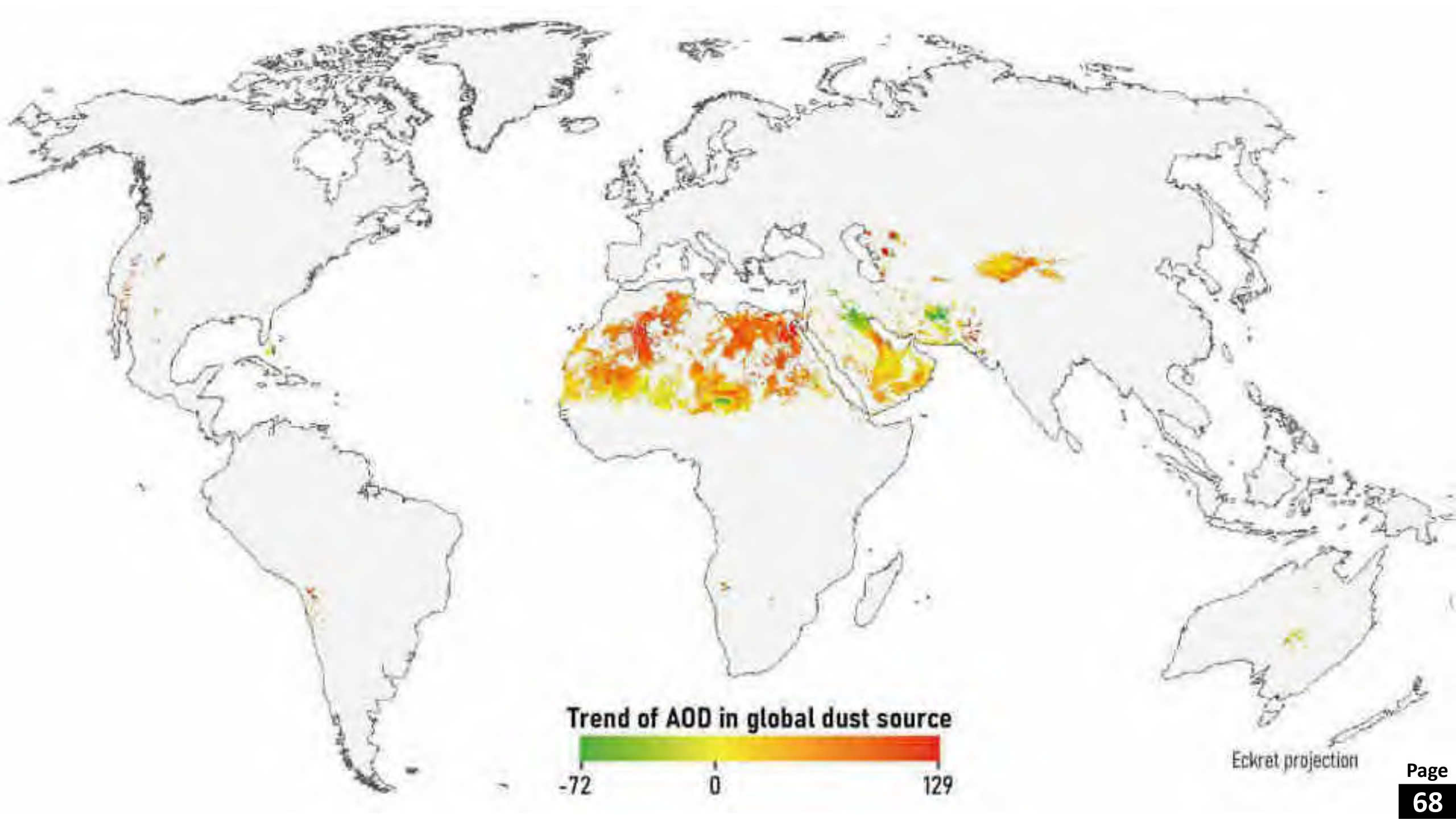
Dust Source

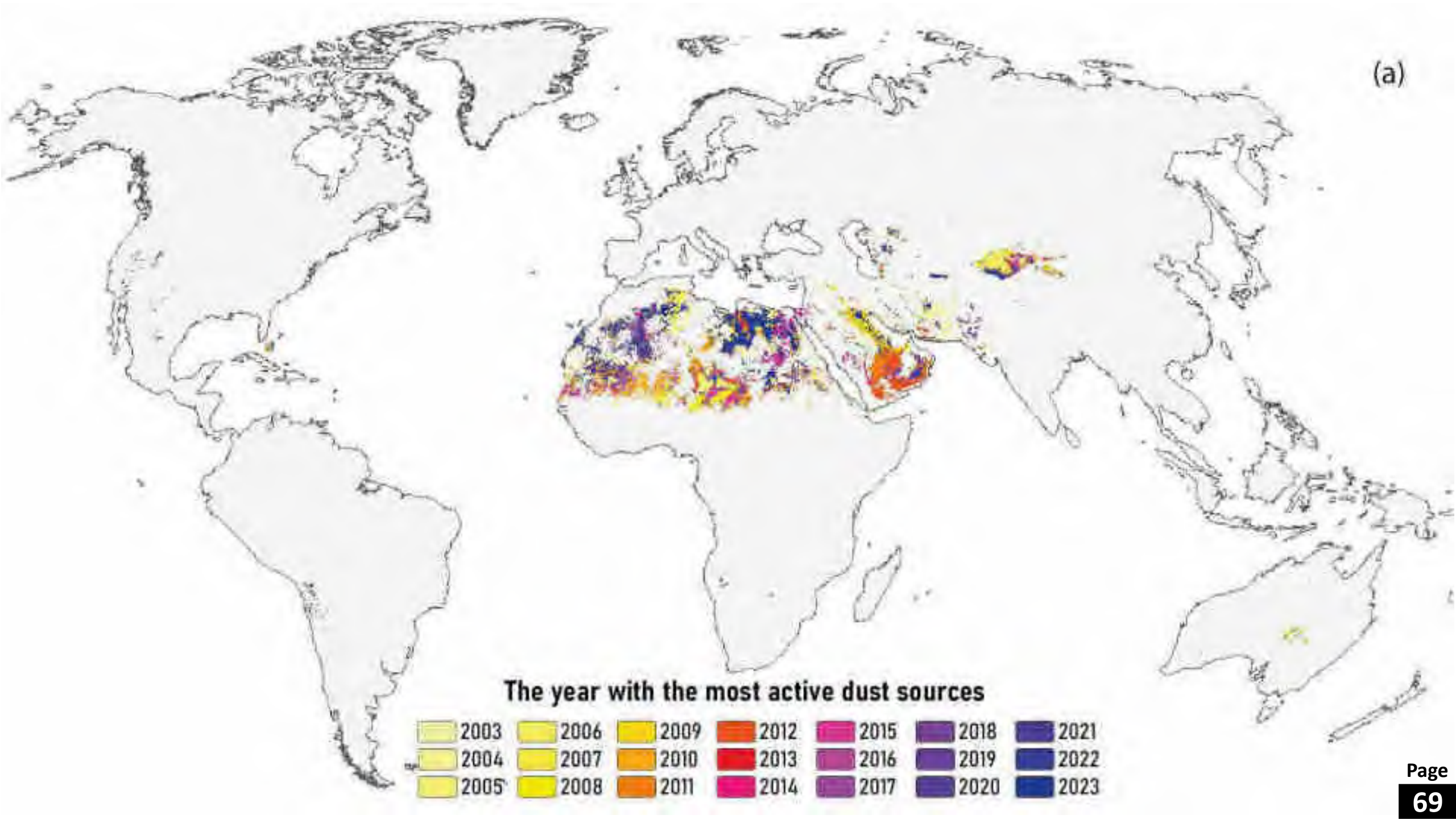

2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020

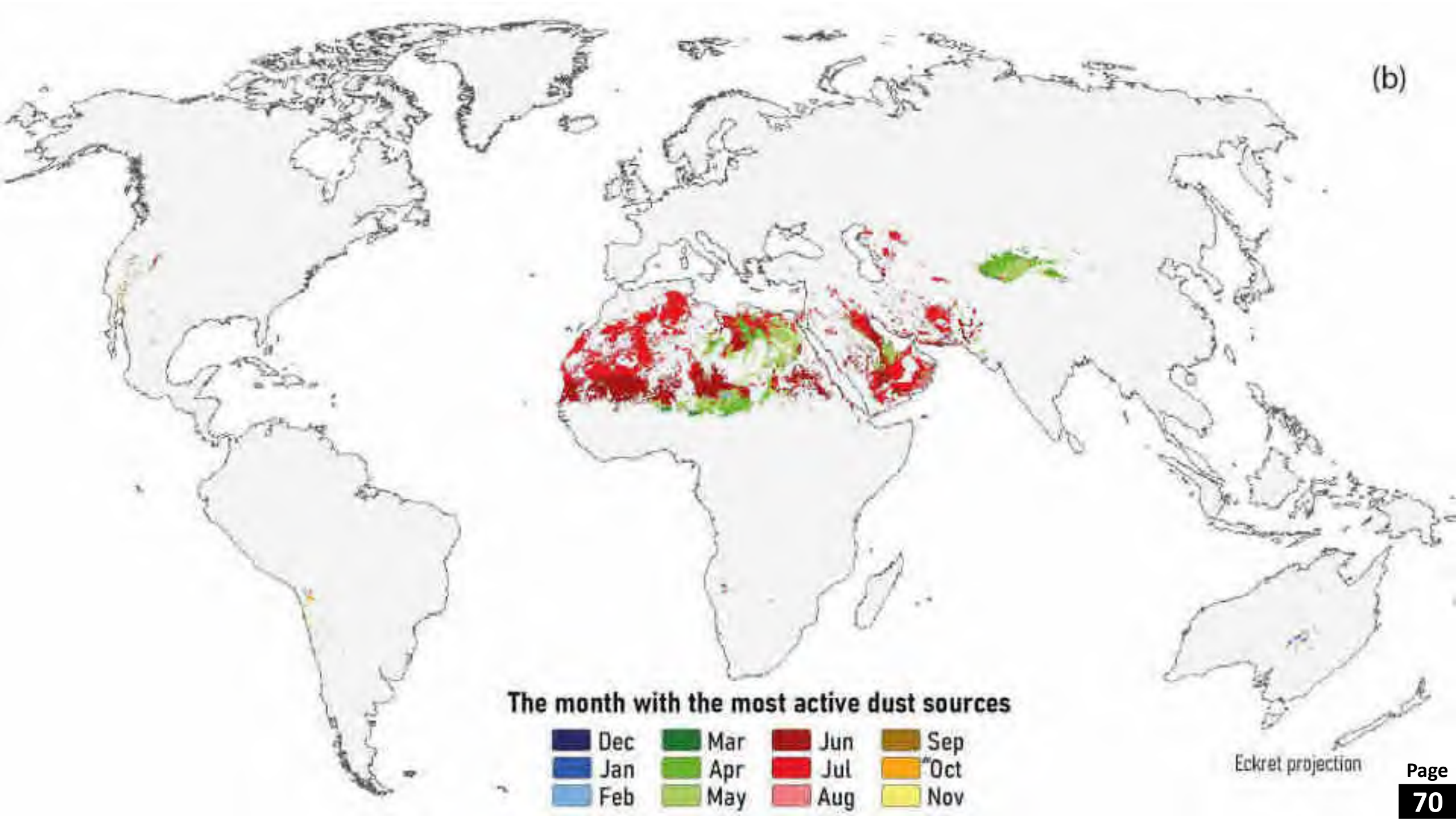
Dust Source


January
February
March
April
May
June
July
August
September
October
November
December


10°W
0°
10°E
20°E
30°E
40°E
50°E
60°E
30°N
20°N
Morocco
Algeria
Libya
Egypt
Sudan
Iraq
Iran
Saudi Arabia
Oman
Yemen
Dust source
Highly active
Moderately active
Low active

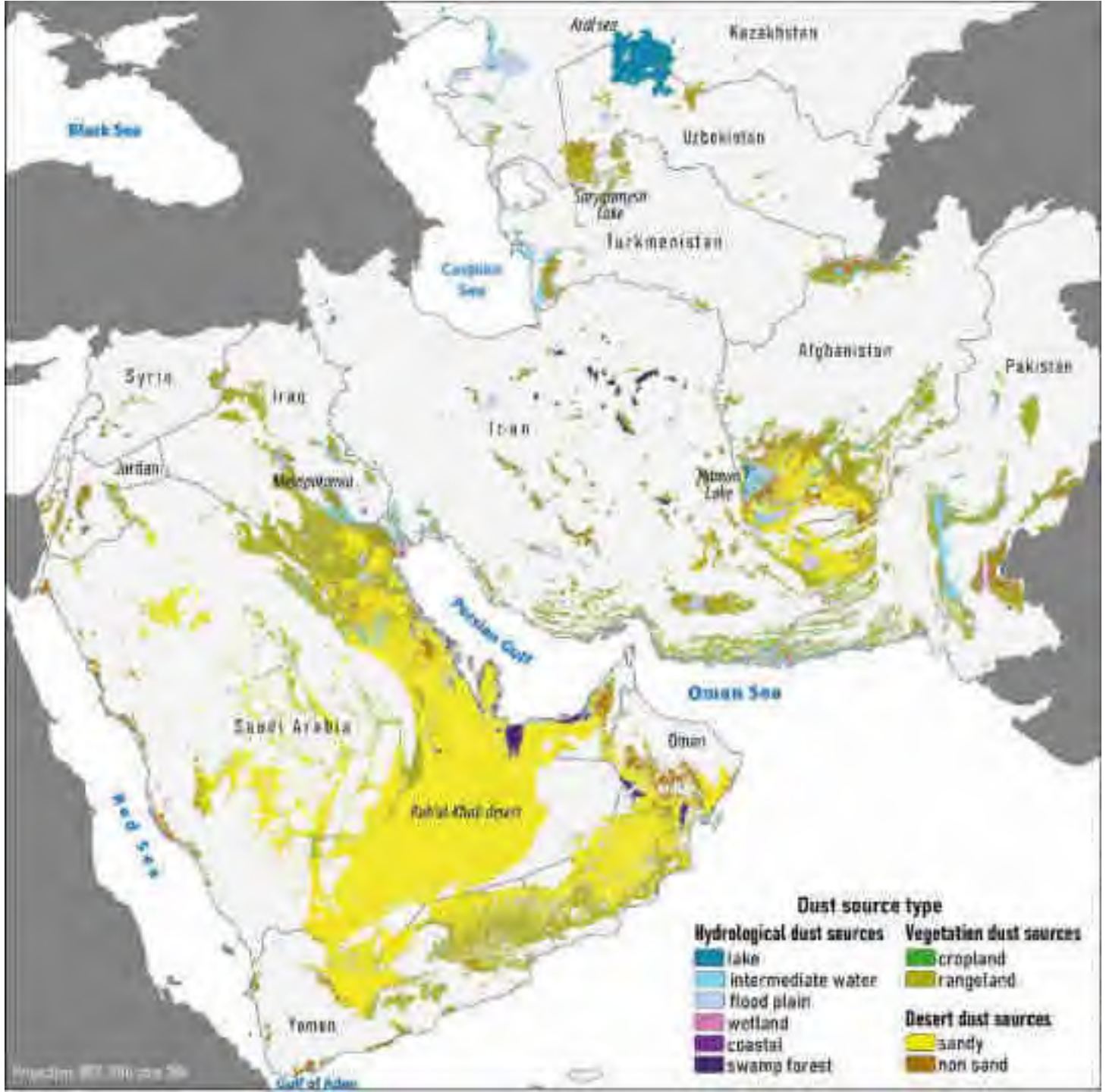

Trend of AOD in global dust source
-72
0
129
Eckret projection

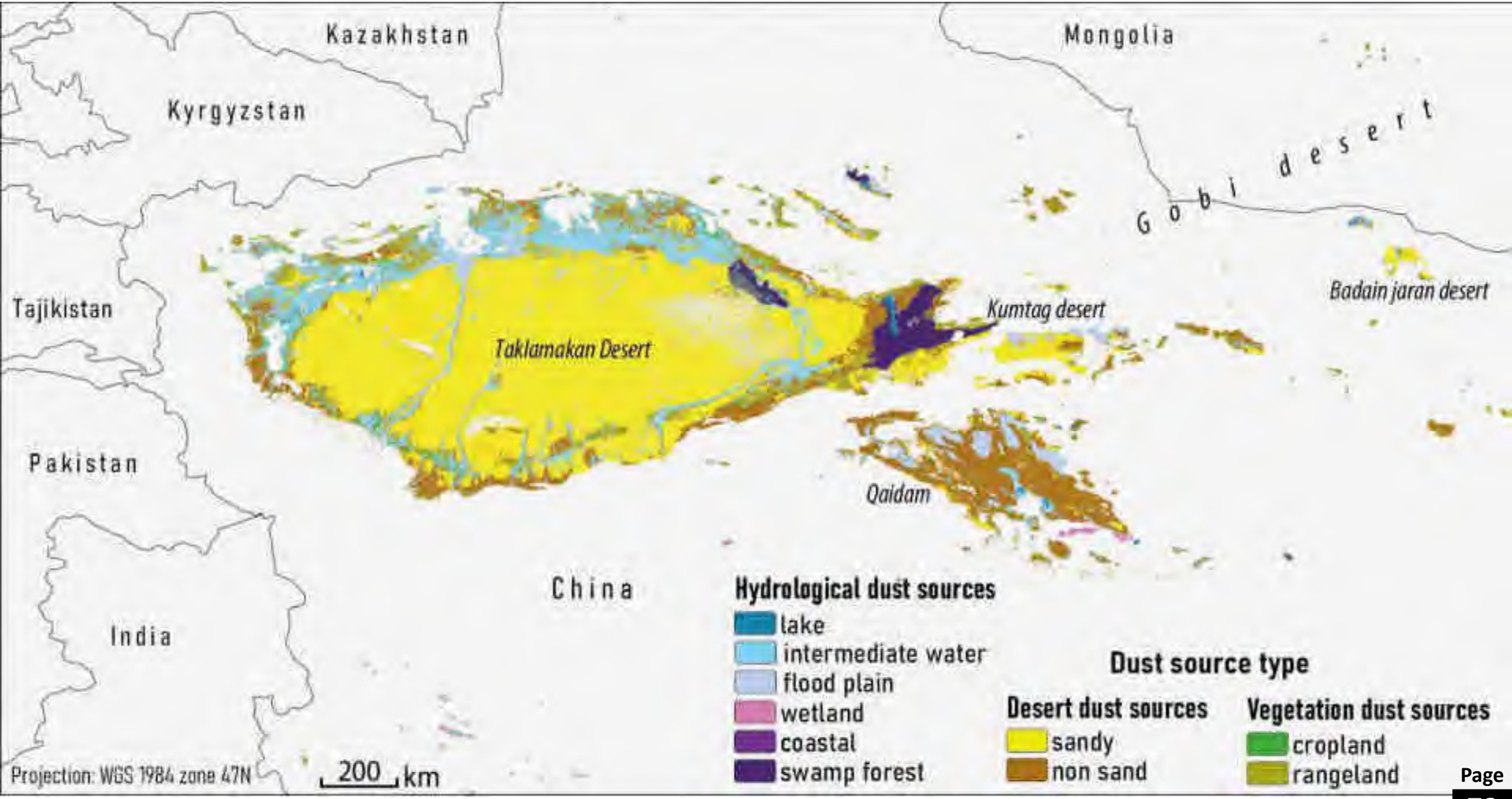

(a)
The year with the most active dust sources
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023

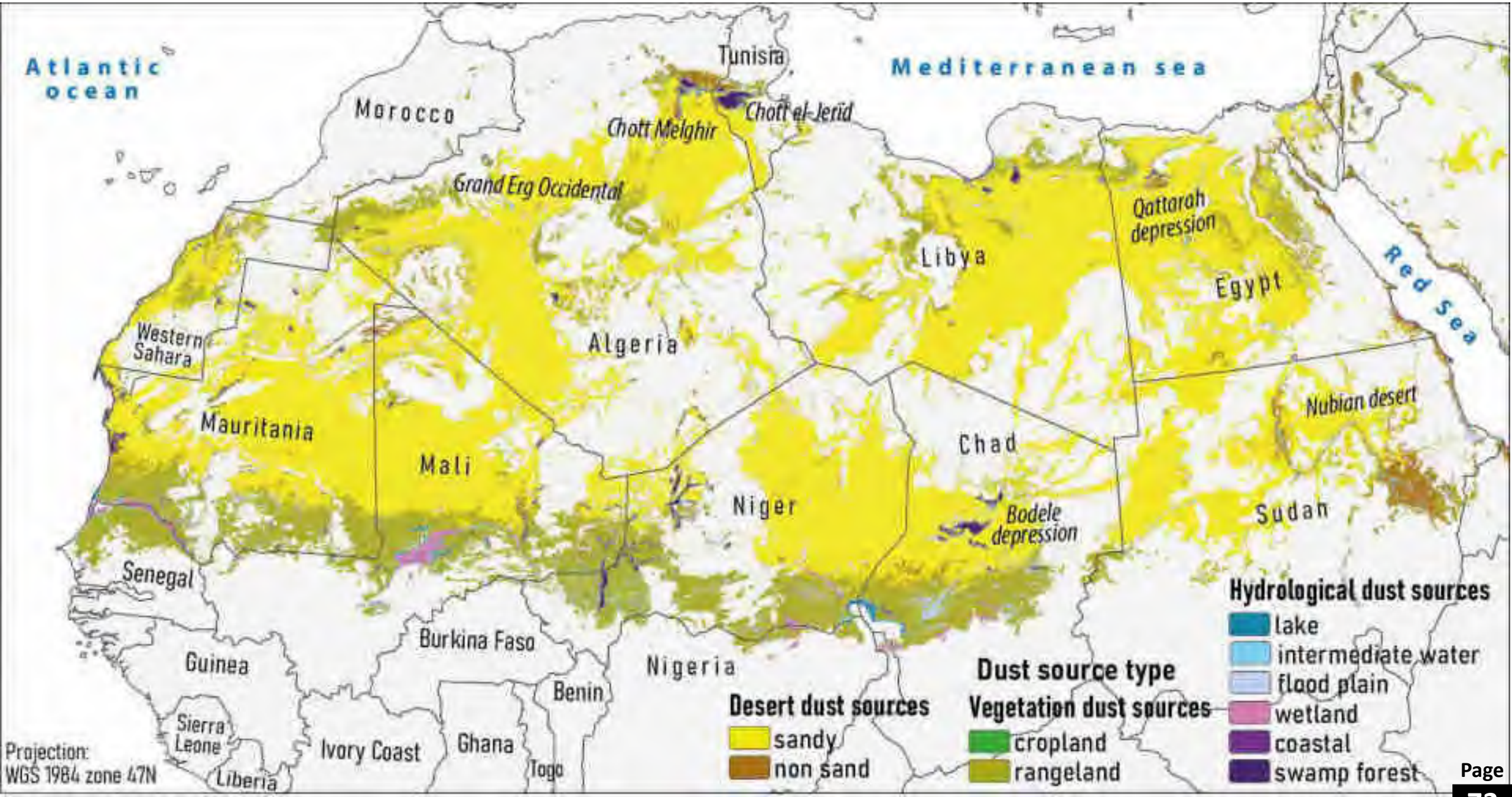

(b)
The month with the most active dust sources
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Eckret projection

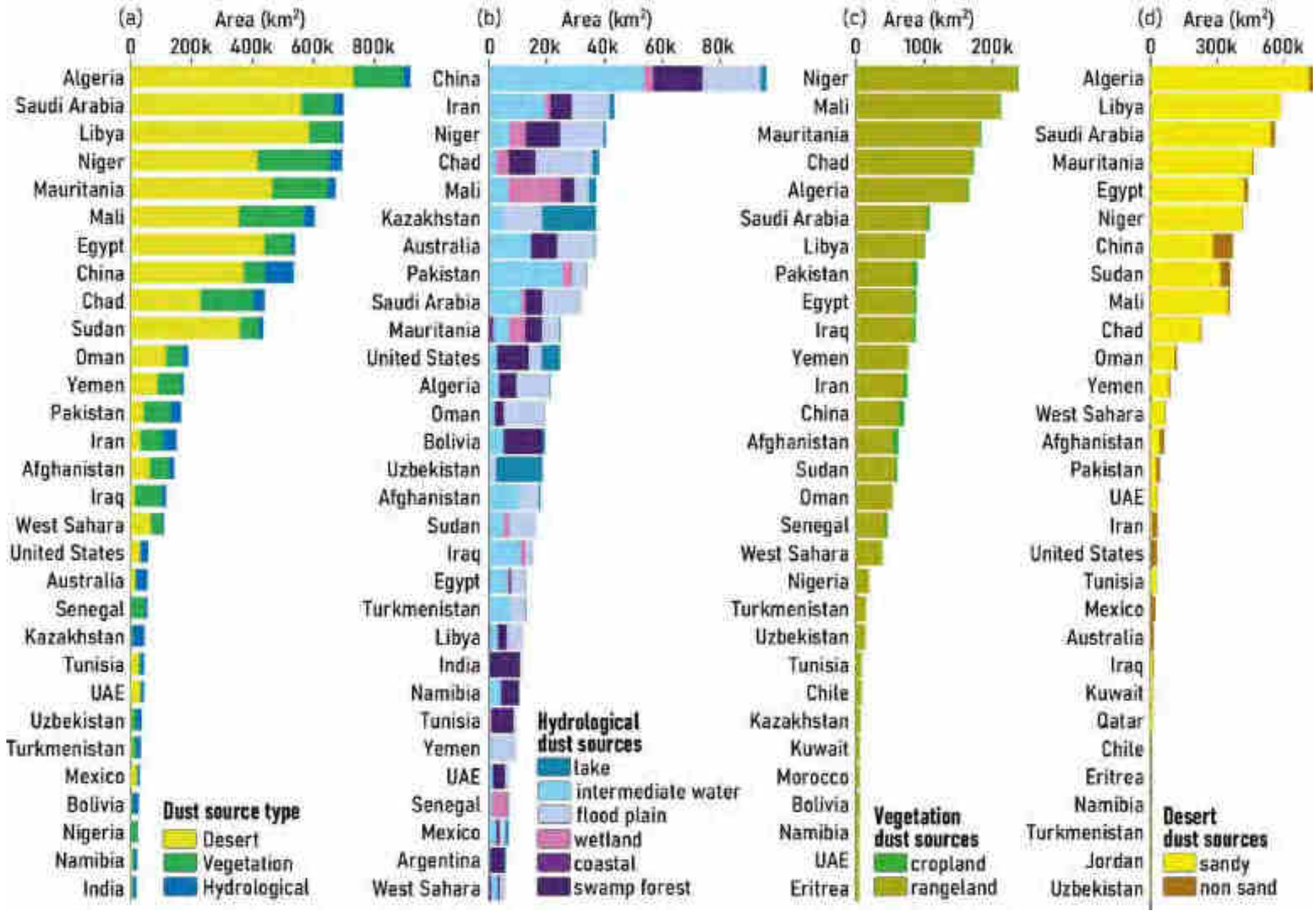
ECO

National Cartographic Center of IRAN



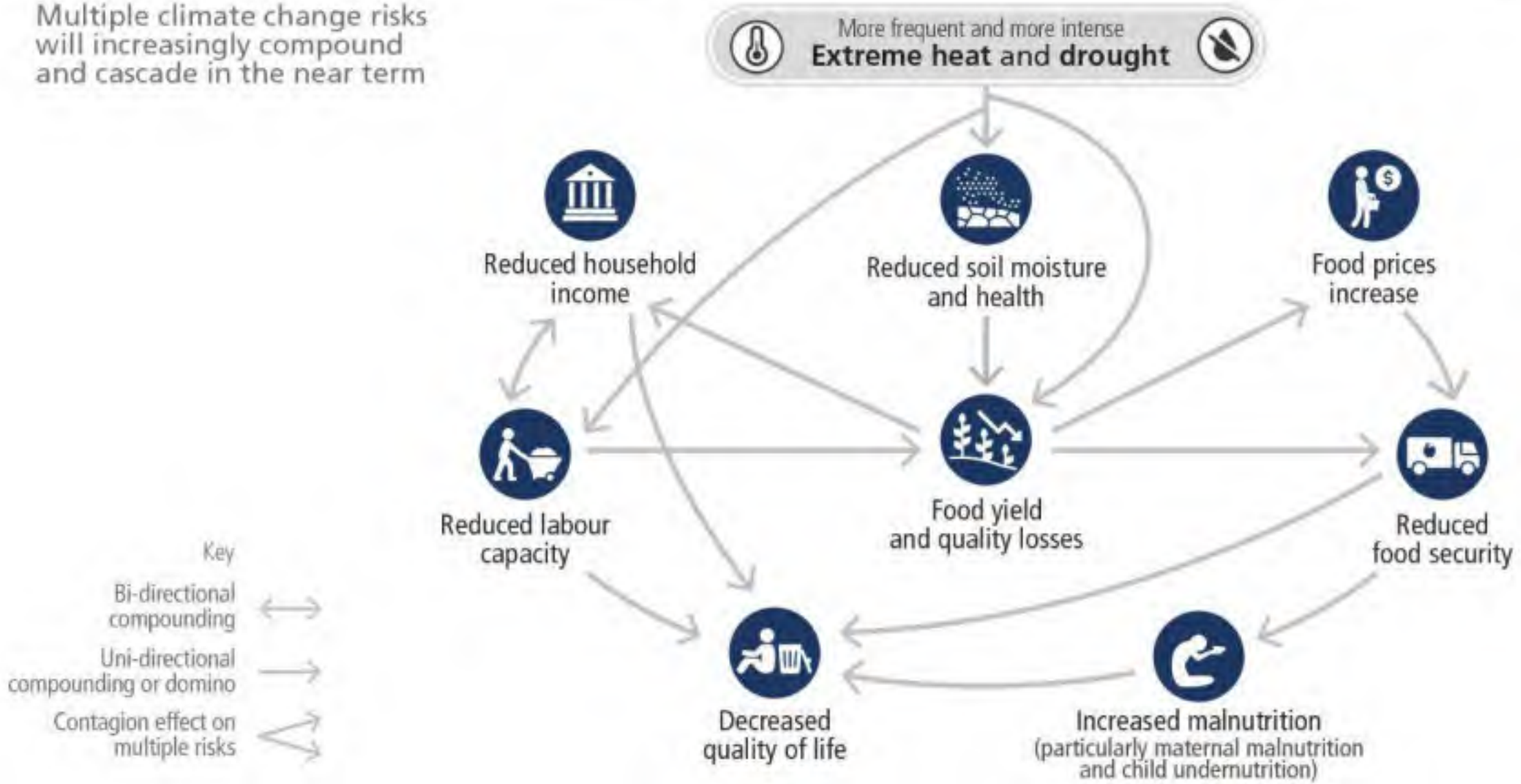

Kazakhstan
Kyrgyzstan
Tajikistan
Pakistan
India
China
Mongolia
Gobi desert
Badain jaran desert
Kumtag desert
Taklamakan Desert
Qaidam
Hydrological dust sources
lake
intermediate water
flood plain
wetland
coastal
swamp forest
Dust source type
Desert dust sources
sandy
non sand
Vegetation dust sources
cropland
rangeland
Projection: WGS 1984 zone 47N
200 km


Atlantic ocean
Mediterranean sea
Red Sea
Tunisia
Morocco
Chott Melghir
Chott el-Jerid
Grand Erg Occidental
Libya
Qattarah depression
Egypt
Western Sahara
Algeria
Mauritania
Mali
Niger
Chad
Nubian desert
Sudan
Bodele depression
Senegal
Burkina Faso
Guinea
Nigeria
Benin
Sierra Leone
Ivory Coast
Ghana
Togo
Liberia
Projection:
WGS 1984 zone 47N
Desert dust sources
sandy
non sand
Dust source type
Vegetation dust sources
cropland
rangeland
Hydrological dust sources
lake
intermediate water
flood plain
wetland
coastal
swamp forest


(a)
Area (km²)
0
200k
400k
600k
800k
Algeria
Saudi Arabia
Libya
Niger
Mauritania
Mali
Egypt
China
Chad
Sudan
Oman
Yemen
Pakistan
Iran
Afghanistan
Iraq
West Sahara
United States
Australia
Senegal
Kazakhstan
Tunisia
UAE
Uzbekistan
Turkmenistan
Mexico
Bolivia
Nigeria
Namibia
India
Dust source type
Desert
Vegetation
Hydrological
(b)
Area (km²)
0
20k
40k
60k
80k
China
Iran
Niger
Chad
Mali
Kazakhstan
Australia
Pakistan
Saudi Arabia
Mauritania
United States
Algeria
Oman
Bolivia
Uzbekistan
Afghanistan
Sudan
Iraq
Egypt
Turkmenistan
Libya
India
Namibia
Tunisia
Yemen
UAE
Senegal
Mexico
Argentina
West Sahara
Hydrological dust sources
lake
intermediate water
flood plain
wetland
coastal
swamp forest
(c)
Area (km²)
0
100k
200k
Niger
Mali
Mauritania
Chad
Algeria
Saudi Arabia
Libya
Pakistan
Egypt
Iraq
Yemen
Iran
China
Afghanistan
Sudan
Oman
Senegal
West Sahara
Nigeria
Turkmenistan
Uzbekistan
Tunisia
Chile
Kazakhstan
Kuwait
Morocco
Bolivia
Namibia
UAE
Eritrea
Vegetation dust sources
cropland
rangeland
(d)
Area (km²)
0
300k
600k
Algeria
Libya
Saudi Arabia
Mauritania
Egypt
Niger
China
Sudan
Mali
Chad
Oman
Yemen
West Sahara
Afghanistan
Pakistan
UAE
Iran
United States
Tunisia
Mexico
Australia
Iraq
Kuwait
Qatar
Chile
Eritrea
Namibia
Turkmenistan
Jordan
Uzbekistan
Desert dust sources
sandy
non sand

Climate change

c) Example of complex risk, where impacts from climate extreme events have cascading effects on food, nutrition, livelihoods and well-being of smallholder farmers



a) AR5 IPCC Risk Framework

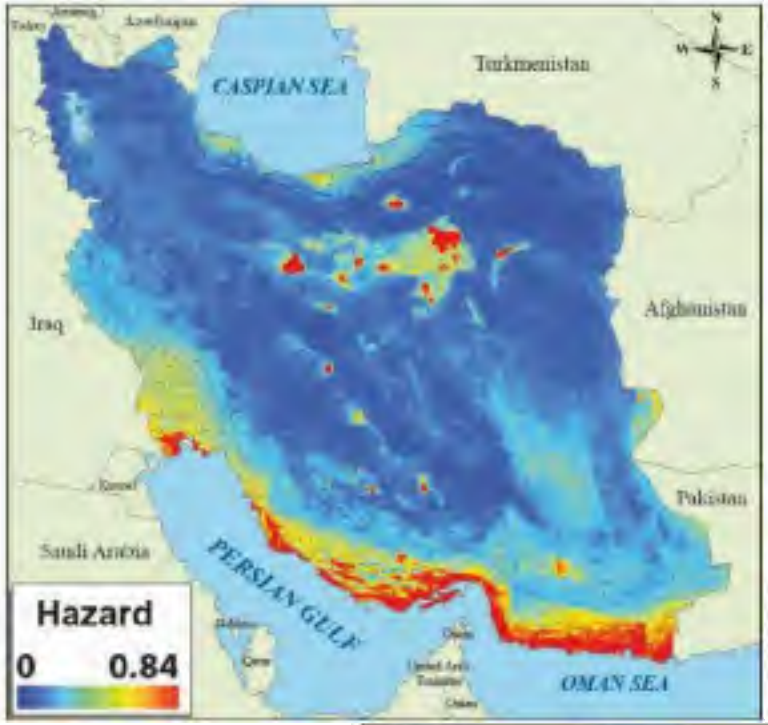
b) AR6 and future of the IPCC Risk Framework

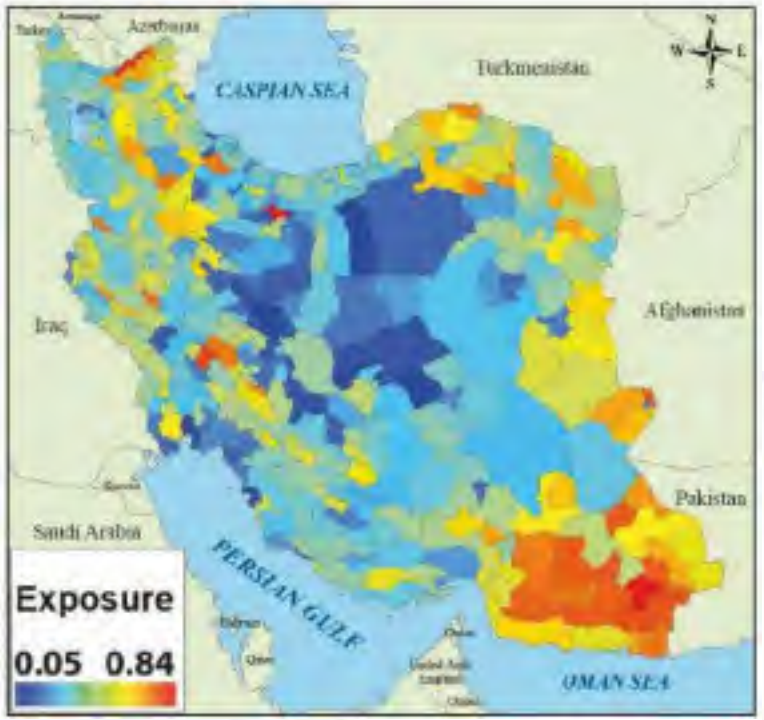
ECO

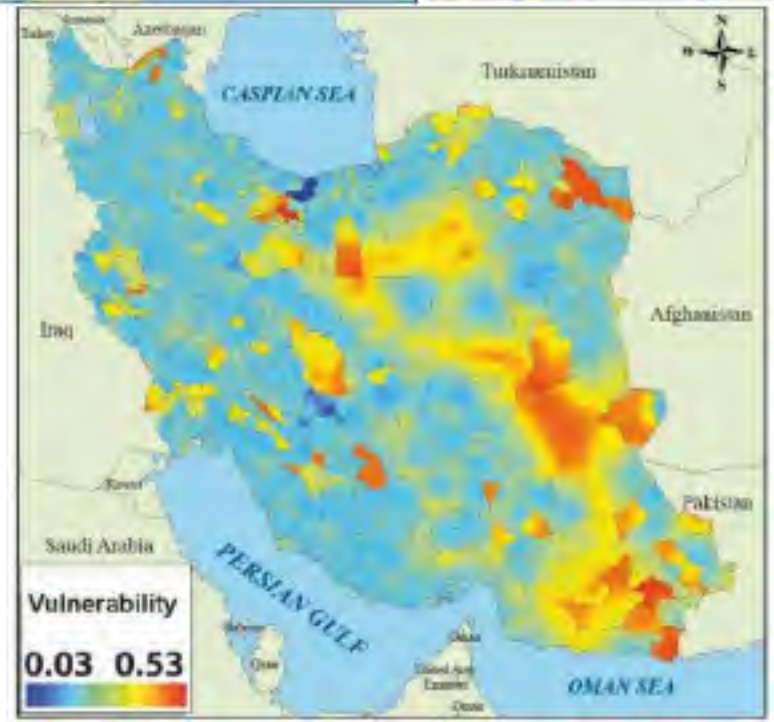
National Cartographic Center of IRAN

Risk = Vulnerability × Hazard × Exposure

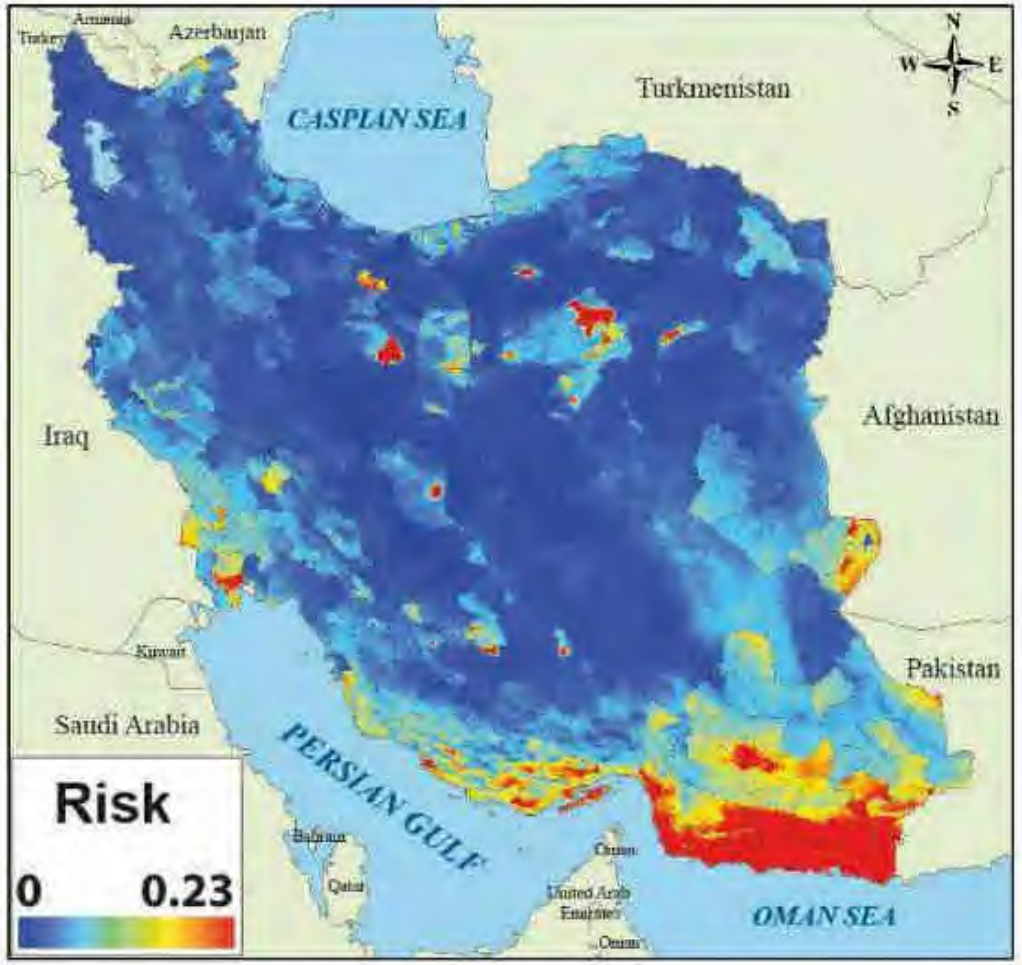
Vulnerability	Hazard	Exposure
Elderly people	Frequency	Population
Heart patients	Intensity	Outside jobs
Respiratory patients	Duration	Trips

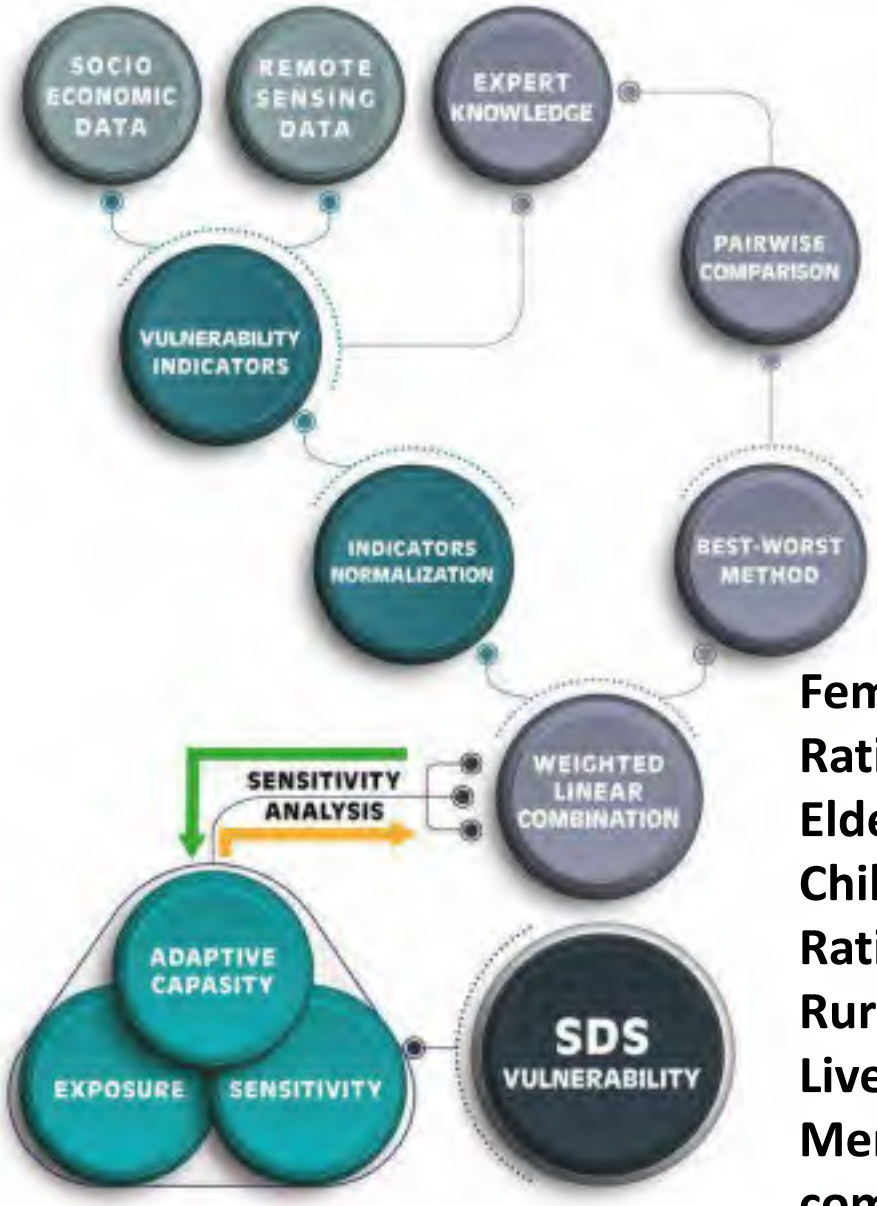




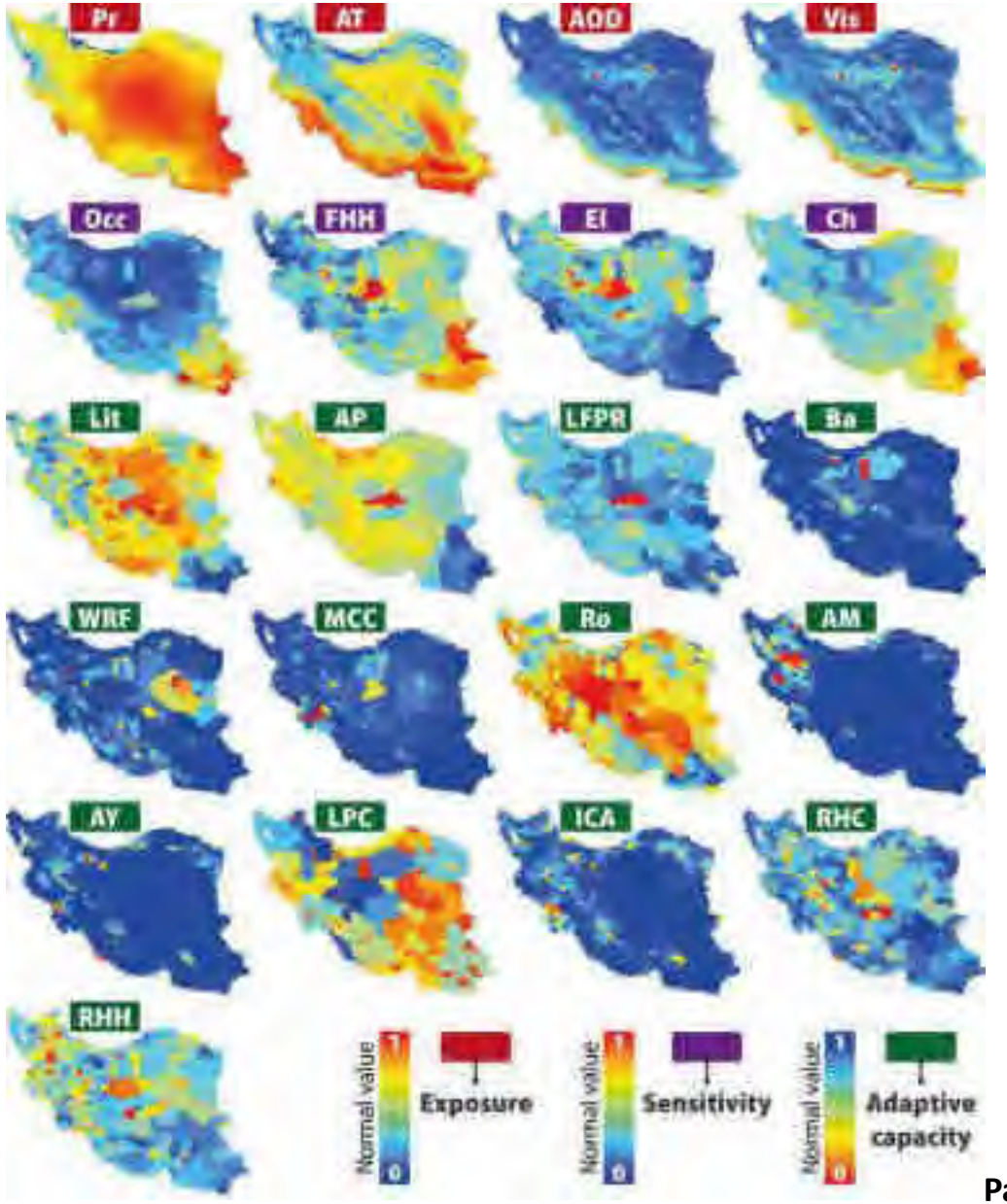


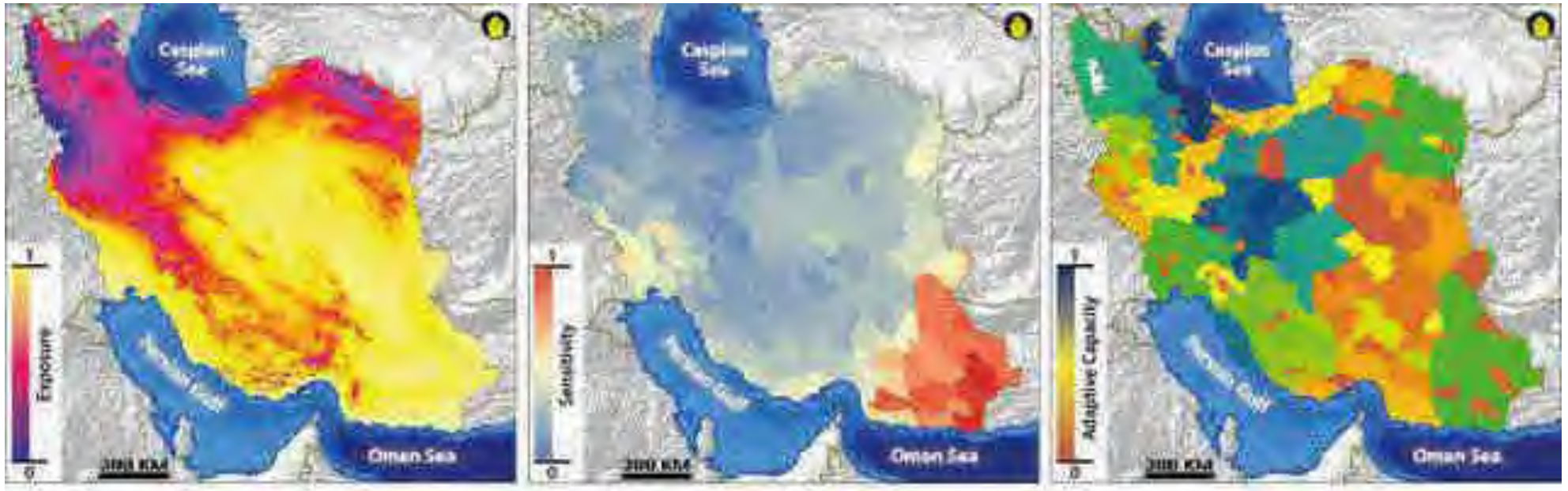
Risk = Vulnerability × Hazard × Exposure

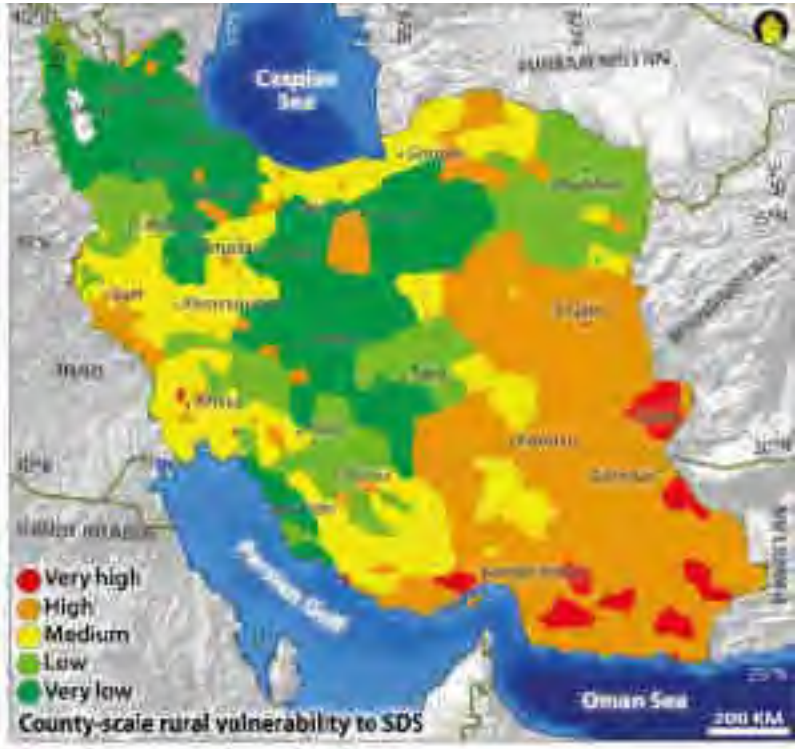




Female-headed households
Ratio of people per dwelling
Elderly
Children
Ratio of banks to people
Rural health centers
Livestock per capita
Membership in cooperative companies
Agricultural machinery …




Caspian Sea
Exposure
Sensitivity
Adaptive Capacity
Oman Sea


Caspian Sea
Very high
High
Medium
Low
Very low
County-scale rural vulnerability to SDS
Oman Sea
200 KM

Caspian Sea
Very high
High
Medium
Low
Very low
Province-scale rural vulnerability to SDS
Oman Sea
200 KM

THANK YOU FOR YOUR ATTENTION!