中国科学院
CHINESE ACADEMY OF SCIENCES

The Risk Characteristics and Control Pilot Test of Desertification in the Central Asia Region

Prof. LEI Jiaqiang
Xinjiang Institute of Ecology & Geography, CAS

25/11/2020, Urumqi

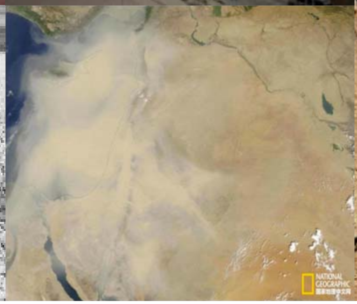
CONTENTS

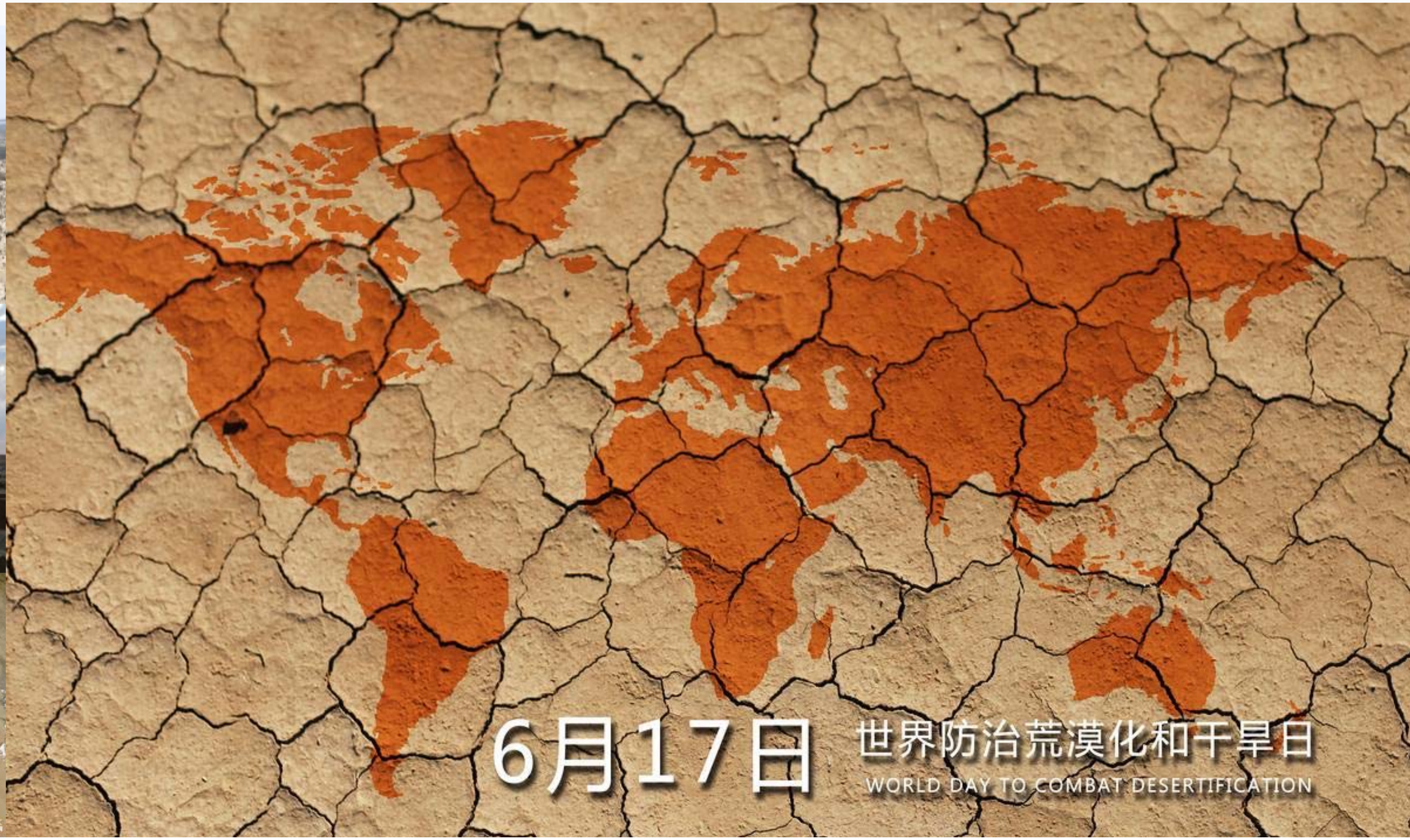
1. Environmental Outline

1.1 Land & Drought

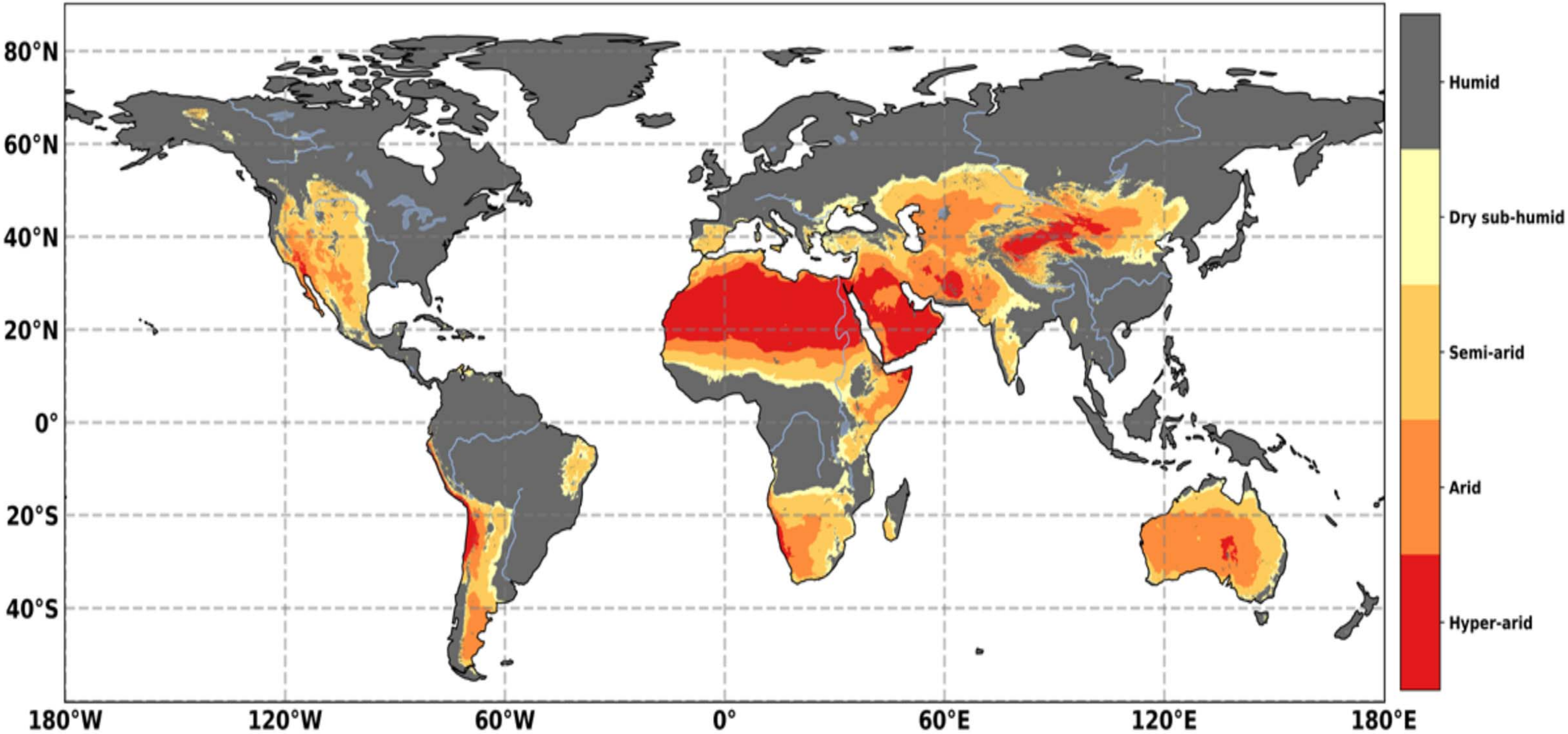
- The global desertification area accounts for 1/4 of the land area, endangers more than 110 countries and more than 1 billion of population and the annual economic loss exceeds 42 billion US dollars
- Desertification has become the most serious eco-environmental problem and also the most rigorous socio-economic problem in the world, especially in arid areas

- The great famine in Africa
- Ecological disaster in the Aral Sea
- Sandstorms in the Middle East





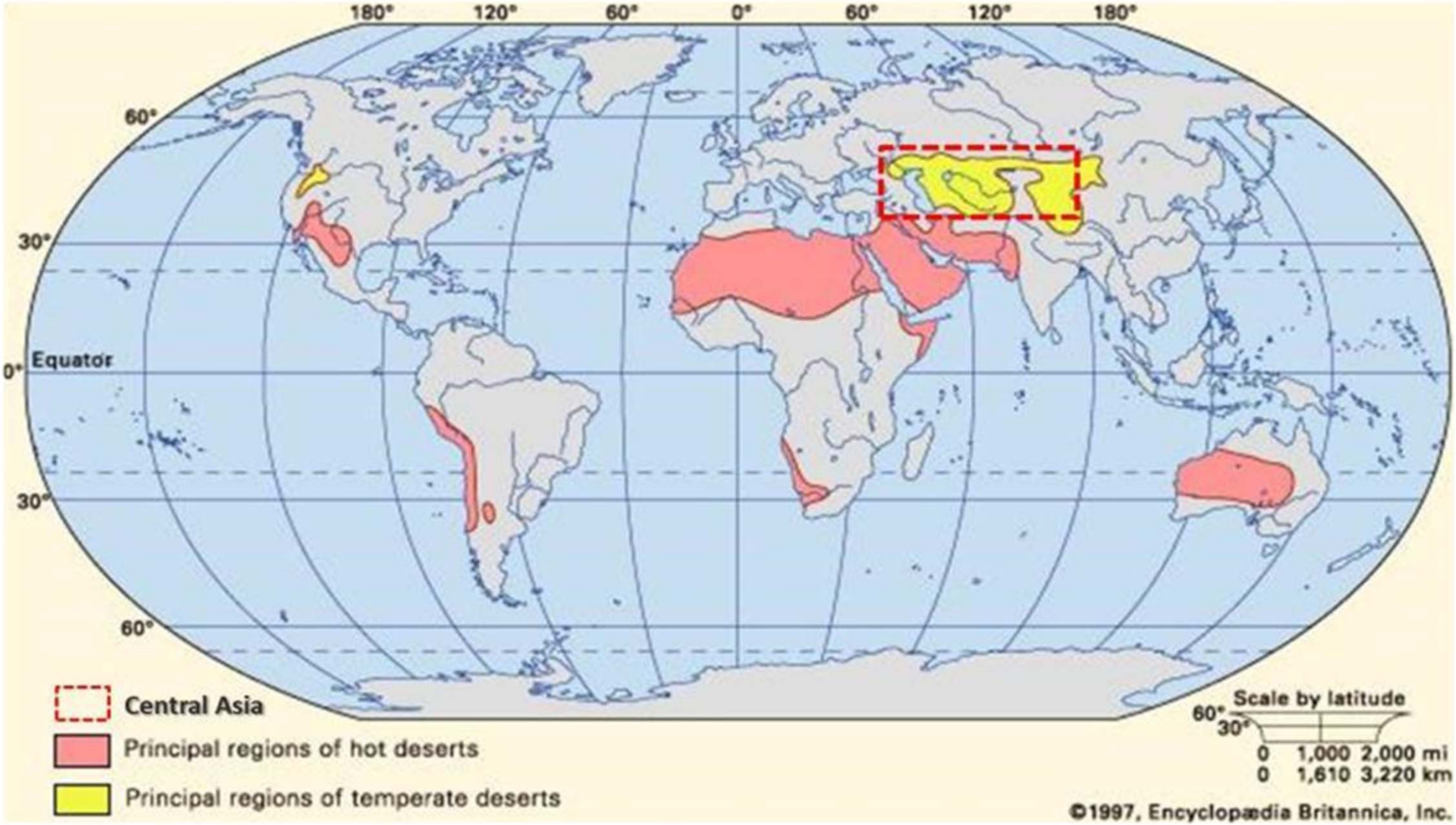
- Arid land accounts for more than 40% of the global land area and more than 2 billion of populations are affected
- Due to the fragile environment, the degradation of arid land is serious and difficult to reverse, or will lead to desertification, sandification and ecosystem collapse



Distribution characteristics of global arid regions based on drought index

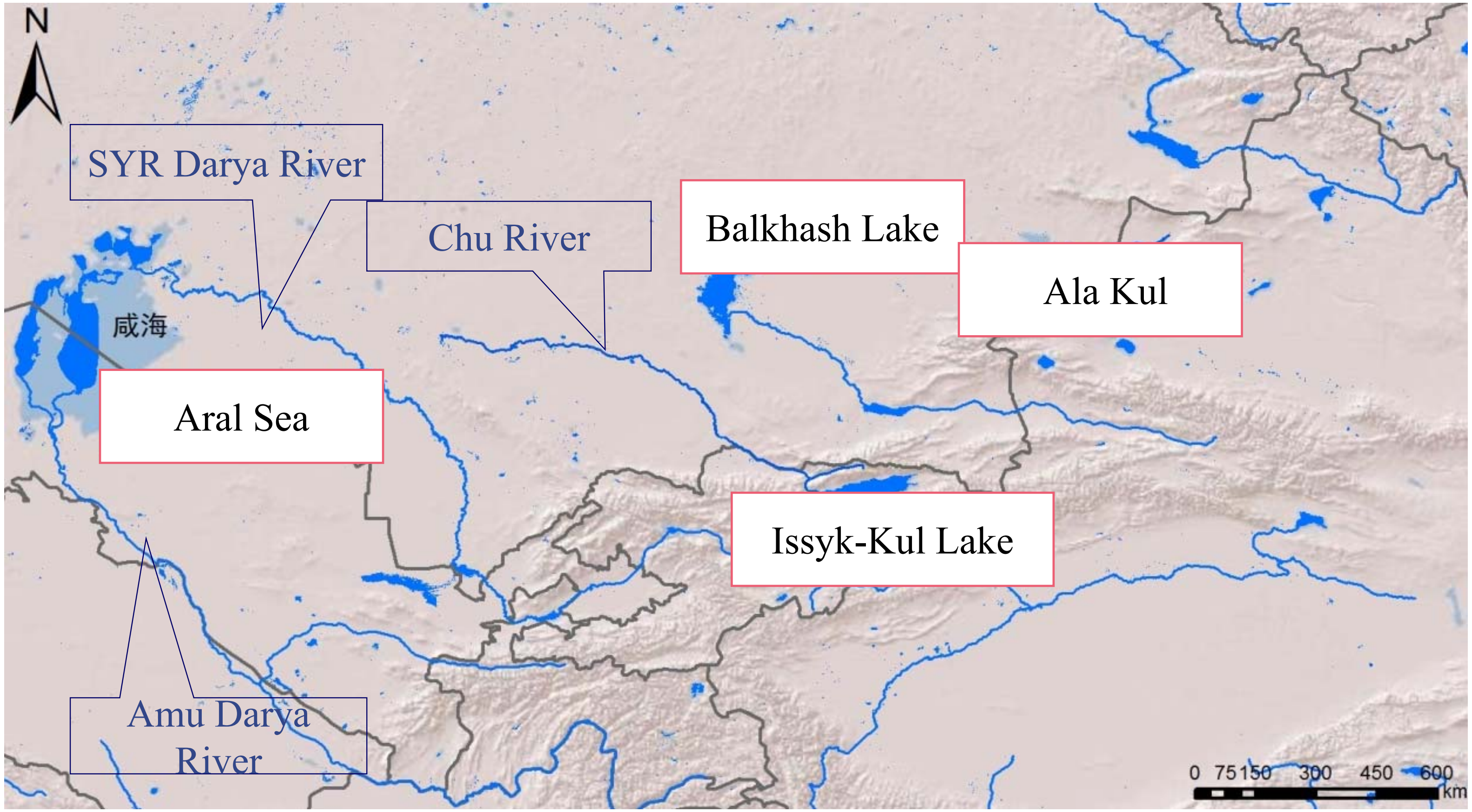
Mirzabaev, A., J. et al., Desertification, IPCC

- About 90% of the world's temperate deserts are distributed in Central Asia



1. Environmental Outline 1.2 Water Resources

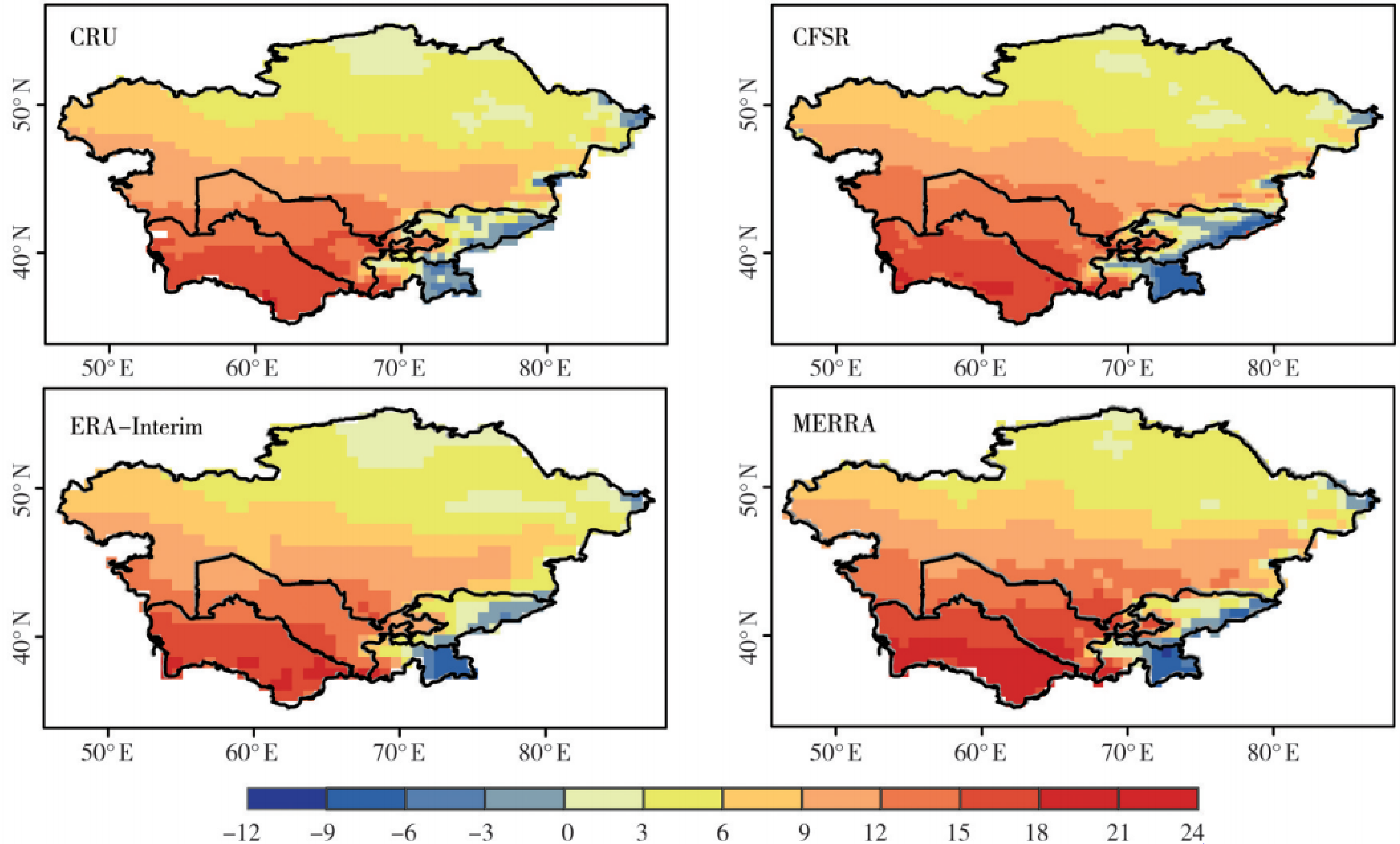
- There are many inland rivers developed in Central Asia, mainly including the SYR Darya River, the Amu Darya River, the Chu River, the Aral Sea, the Balkhash Lake and etc.
- The total volume of fresh water in Central Asia is about 1090 billion m^3, and the available water resources are about 266 billion m^3, including 238 billion m^3 of surface water resources and 28 billion m^3 of groundwater resources



1. Environmental Outline

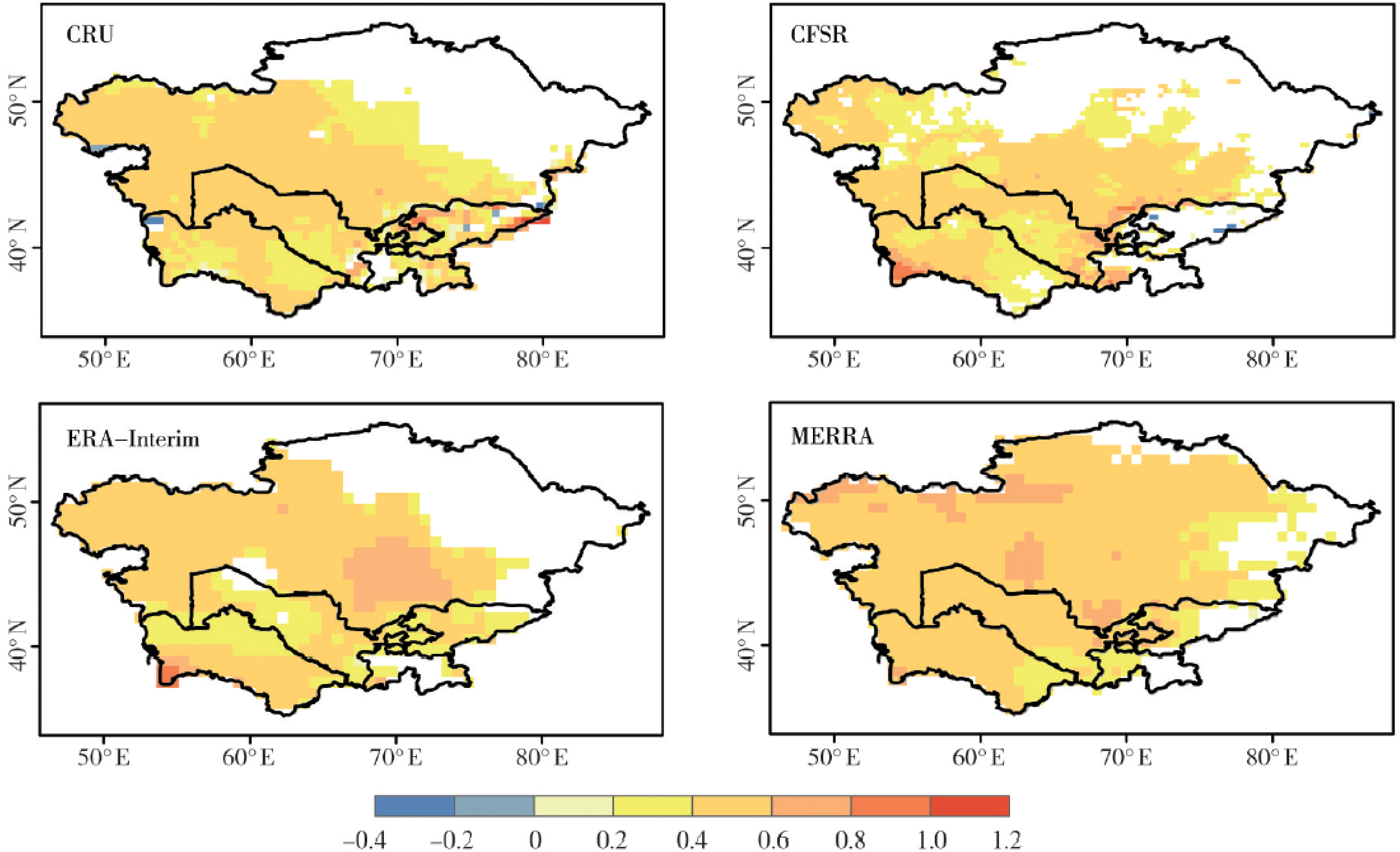
1.3 Climate

- From 1980 to 2011, the temperature was significantly warming, the average temperature growth rate was 0.36 ~ 0.47 ℃ / 10 a. the temperature in Central Asia increased by 1.15 ~ 1.50 ℃ in the past 32 years, which was higher than the growth rate of global average temperature in the same period. In the temperature changes of four seasons, the average temperature increase rate in spring was the highest (0.7 ~0.93 ℃/10 a), but there was no significant change in winter temperature



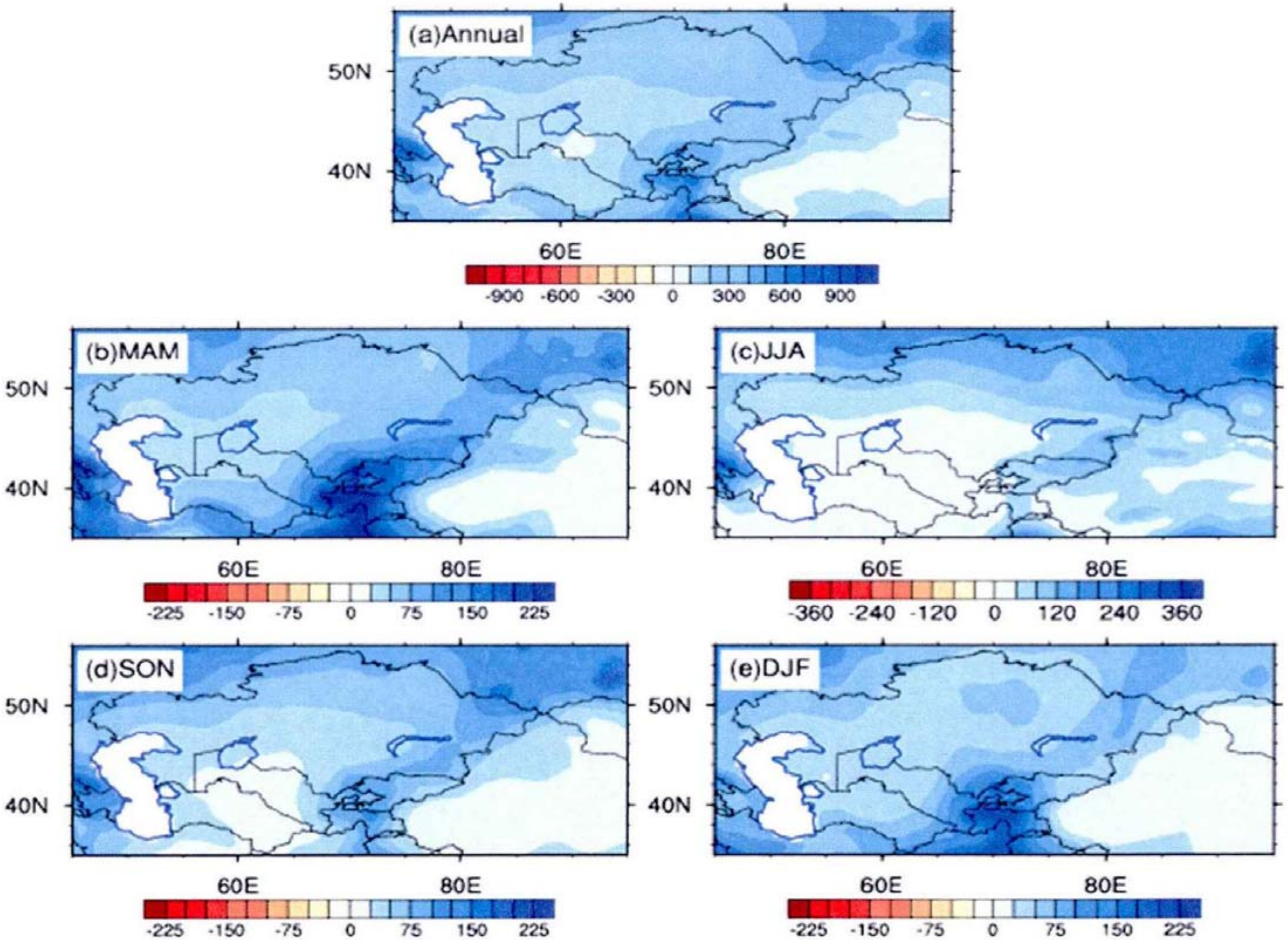
Spatial distribution of mean annual air temperature in Central Asia during 1980-2011 （XU Ting, et.al . 2015）

- In the past 32 years, the central, southern, southwest and western parts of Central Asia have been warming significantly, accounting for 55.36-88.48% of the total area of the region, However, there is no significant change in temperature in the north and east parts, and there is almost no significant cooling area. Among them, the warming in spring is the most significant and the range is the widest, and the significant warming area accounts for 72.58-92.63% of the total area, while the temperature in winter has no significant change.



Spatial distribution of temperature change rate during 1980-2011（XU Ting, et.al . 2015）

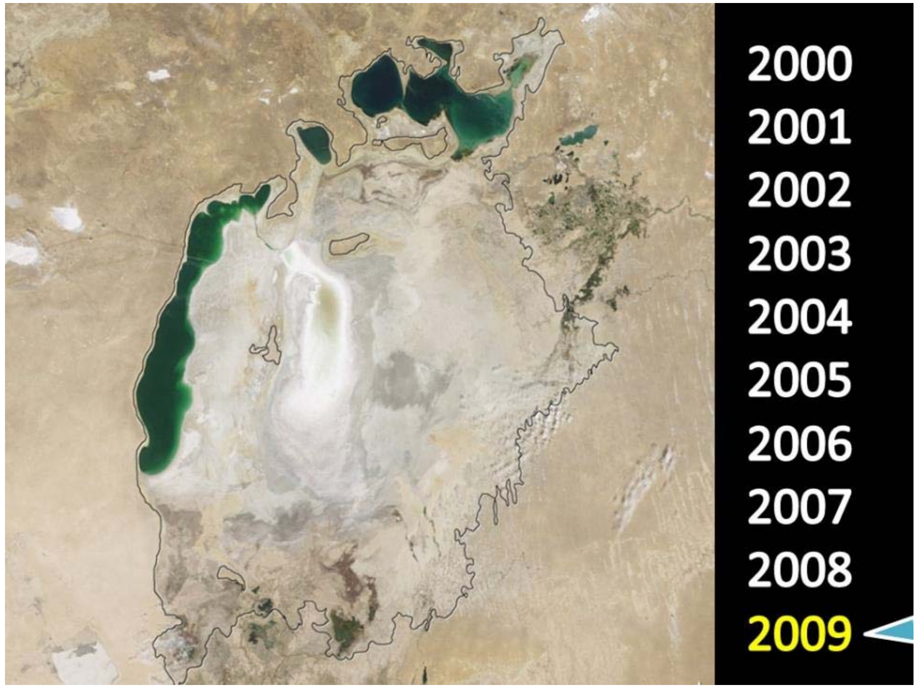
- The rainfall in Central Asia are frequently among 300 ~ 500mm, while the rainfall in central and western parts is less, ＜200mm. To the north along the Aral Sea- the Balkhash Lake line, the rainfall increases with the increase of latitude.
- There are relatively more rainfalls in winter and spring, the rainfalls in summer and autumn is mainly distributed in the north of the Aral Sea- - the Balkhash Lake line



Spatial distribution of annual and seasonal precipitations in Central Asia from 1901 to 2015 (mm)
(Among them, a is year, b is spring, c is summer, d is autumn and e is winter)

1.4 Ecological Degradation

- The ecosystem of Central Asia, which accounts for one third of the world's arid regions, is very fragile and sensitive to climate change and human activities; In recent 40 years, the glaciers in Central Asia have shrunk by 20-30% and the ecosystem has changed dramatically;
- Major ecological events such as the Aral Sea crisis, the dried-up of the Tarim River and others caused by large-scale land reclamation and water-diversion irrigation have attracted global attention.



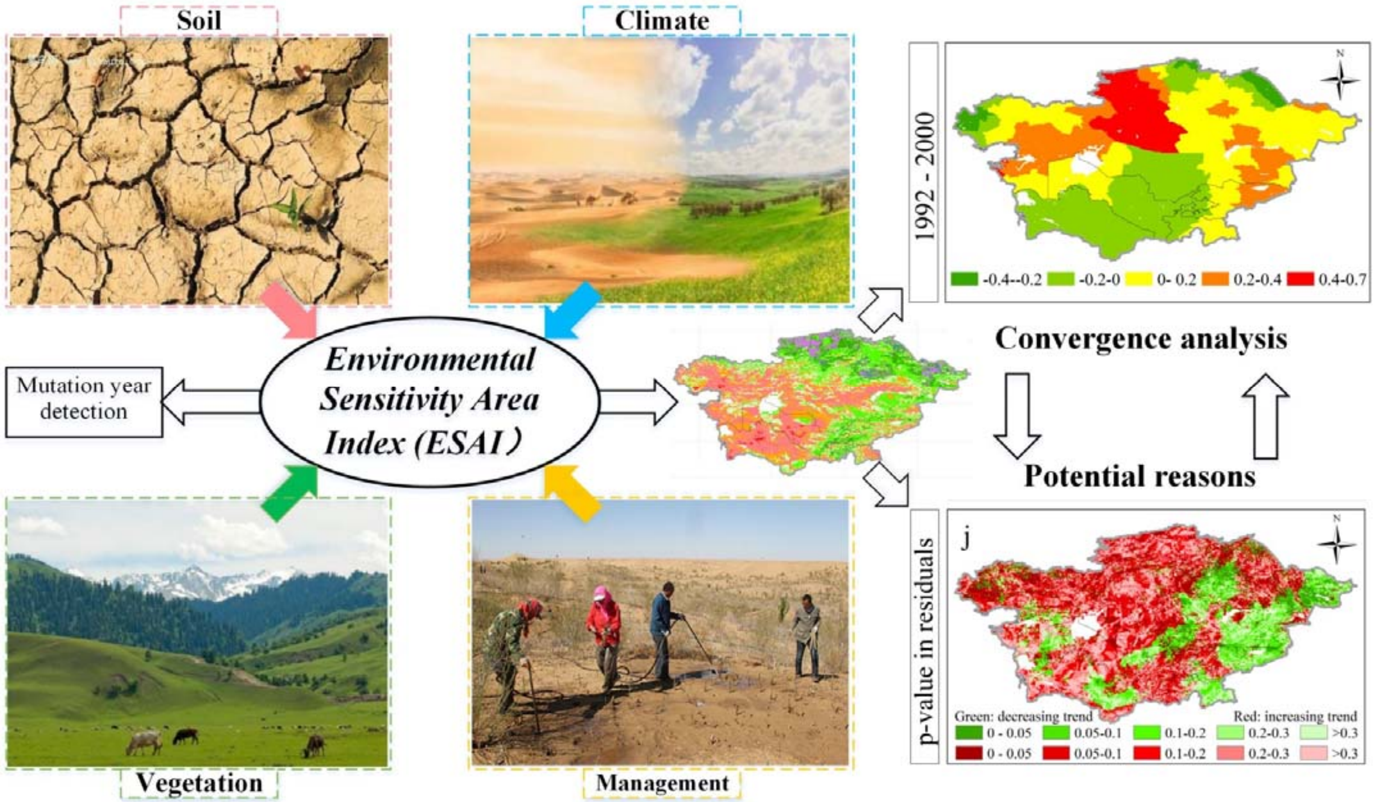
CONTENTS

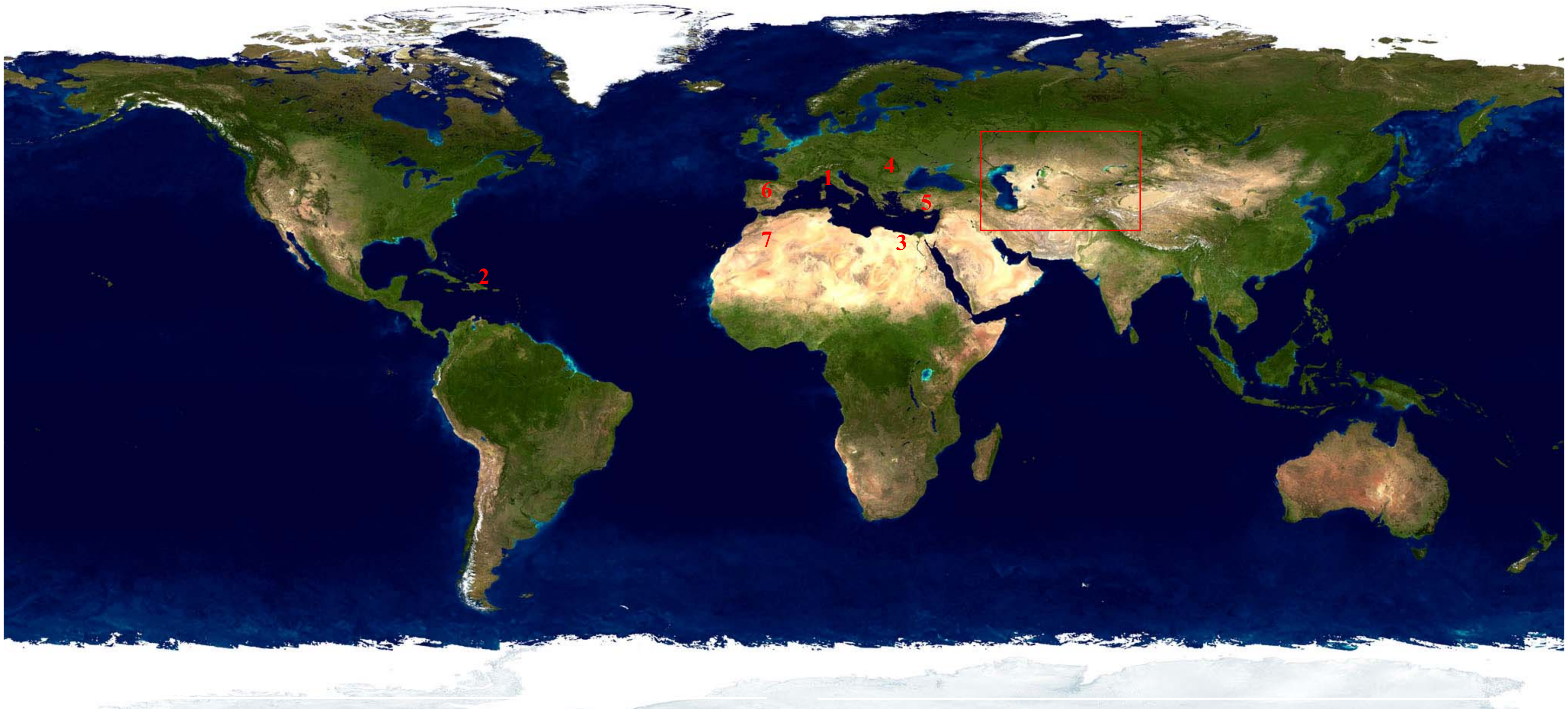
2. Risk Characteristics

2.1 Central Asia

Method

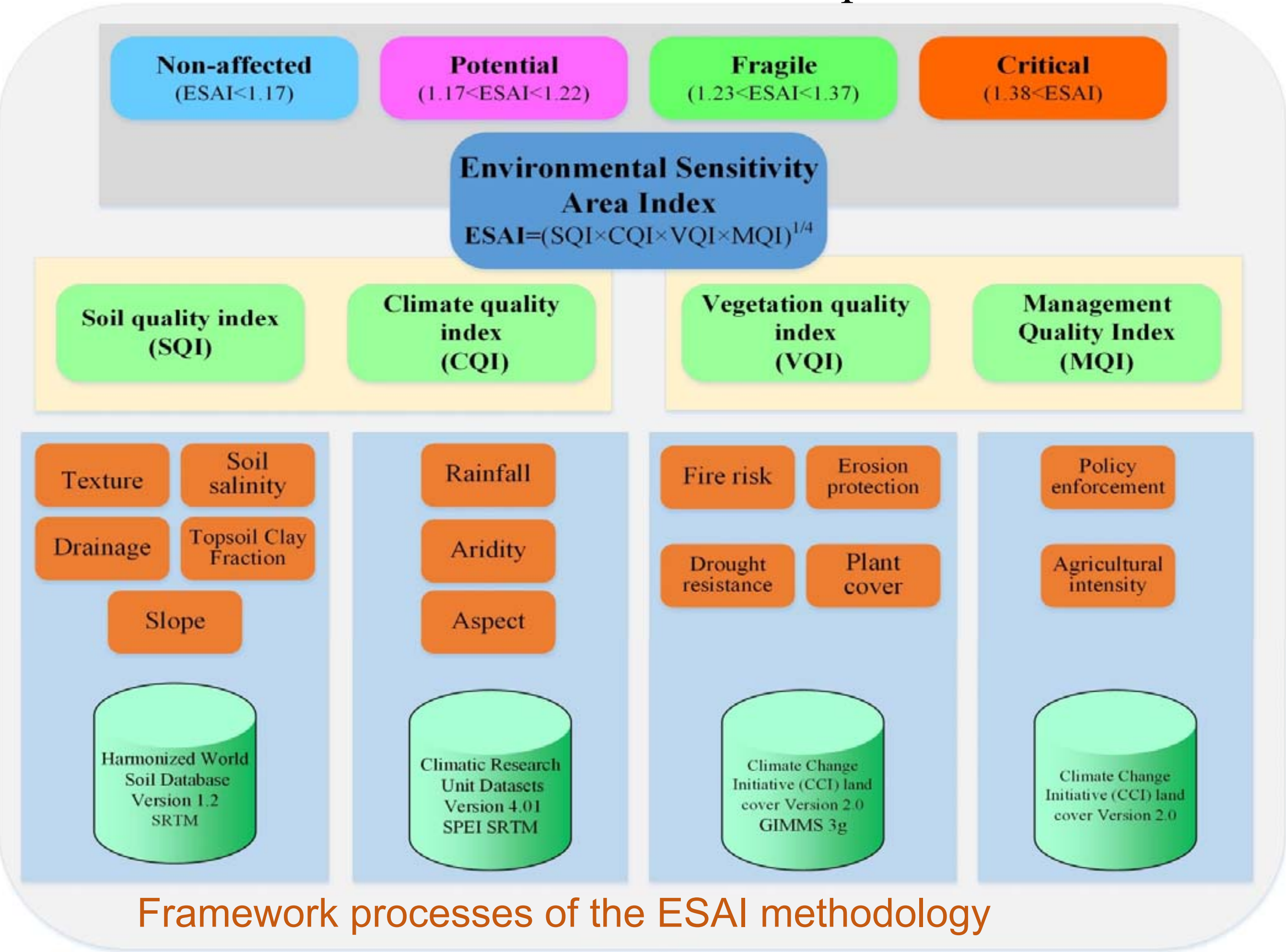
The environmentally sensitive area index (ESAI) method was first utilized to monitor the risk of desertification in Central Asia. Combined with the spatial convergence analysis, we investigated the ESAI convergence processes as revealed by an early warning of desertification risk.





S.N.	Author	Regions	Periodical
1	Salvati	Italy	Land Degrad. Dev. (IF=7.27)
2	Izzo	Dominican	Land Degrad. Dev. (IF=7.27)
3	Bakr	Egypt	Ecological Indicators (IF=3.983)
4	Prăvălie	Romania	Catena (IF=3.256)
5	Symeonakis	Lesvos	Land Degrad. Dev. (IF=7.27)
6	Contador	Spain	Land Degrad. Dev. (IF=7.27)

- The fourteen indicators have been identified to consider four quality domains: soil, climate, vegetation and land management.
- Each quality index was calculated from several indicator parameters.



Framework processes of the ESAI methodology

Indicators

Soil quality index

Indicator	Class	Characteristic	Score
Texture	1	Clay (heavy), Silty clay, Clay (light), Silty clay loam	1
	2	Clay loam, Silt, Silt loam	1.2
	3	Sandy clay, Loam, Sandy clay loam	1.6
	4	Sand, Loamy sand, Sandy loam	2
Soil salinity	1	Null, None or slight, Mainly non-soil, Permafrost area, Water bodies	1
	2	Moderate	1.4
	3	Severe	1.7
	4	Very severe	2
Drainage	1	Well, Moderately well	1
	2	Imperfectly, Somewhat excessive	1.2
	3	Poor, Excessive, Very poor	2
Topsoil clay fraction (%)	1	>25	1
	2	10-25	1.3
	3	<10	2
Slope (%)	1	<6	1
	2	6-18	1.2
	3	18-35	1.5
	4	>35	2

$$SQI = (\text{texture} \times \text{soil salinity} \times \text{drainage} \times \text{topsoil clay fraction} \times \text{slope})^{1/5}$$

Vegetation quality index

Indicator	Class	Characteristic	Score
Fire risk	1	Bare land, Perennial agricultural crop, Annual agricultural crop	1
	2	Evergreen forest, Mixed forest	1.3
	3	Shrub, Grassland	1.6
	4	Evergreen forest	2
Erosion protection	1	Broadleaved forest, Mixed forest	1
	2	Shrub, Grassland,	1.3
	3	Deciduous forest	1.6
	4	Perennial agricultural crop	1.8
	5	Annual agricultural crop, Bare land	2
Drought resistance	1	Mixed forest, Evergreen forest	1
	2	Deciduous forest	1.2
	3	Perennial agricultural tree	1.4
	4	Perennial grassland, Shrub	1.7
	5	Annual agricultural crop, Annual grasslands, bare land	2
Plant cover (%)	1	>40	1
	2	10-40	1.5
	3	<10	2

$$VQI = (\text{fire risk} \times \text{erosion protection} \times \text{drought resistance} \times \text{plant cover})^{1/4}$$

Climate quality index

Indicator	Class	Characteristic	Score
Rainfall (mm)	1	>650	1
	2	280-650	1.5
	3	<280	2
Aridity	1	>0	1
	2	-0.8-0	1.2
	3	-0.8--1.6	1.4
	4	-2.4--1.6	1.8
	5	<-2.4	2
Aspect	1	NW−NE	1
	2	SW−SE	2

Management quality index

Indicator	Class	Characteristic	Score
Agricultural intensity	1	Natural vegetation, forest, beaches, dunes, sands	1
	2	Rainfed cropland, cropland with natural vegetation	1.5
	3	Permanently irrigated land	2
Policy enforcement	1	Permanently irrigated land, broadleaved forest	1
	2	Cropland with natural vegetation	1.5
	3	Rainfed cropland, natural vegetation, forest, beaches, dunes, sands	2

$$CQI = (\text{rainfall} \times \text{aridity} \times \text{slope aspect})^{1/3}$$

$$MQI = (\text{agricultural intensity} \times \text{policy enforcement})^{1/2}$$

$$ESAI = (\text{SQI}_{i,j} \times CQI_{i,j} \times VQI_{i,j} \times MQI_{i,j})^{1/4}$$

Non-affected (ESAI<1.17)

Potential (1.17<ESAI<1.22)

Fragile (1.23<ESAI<1.37)

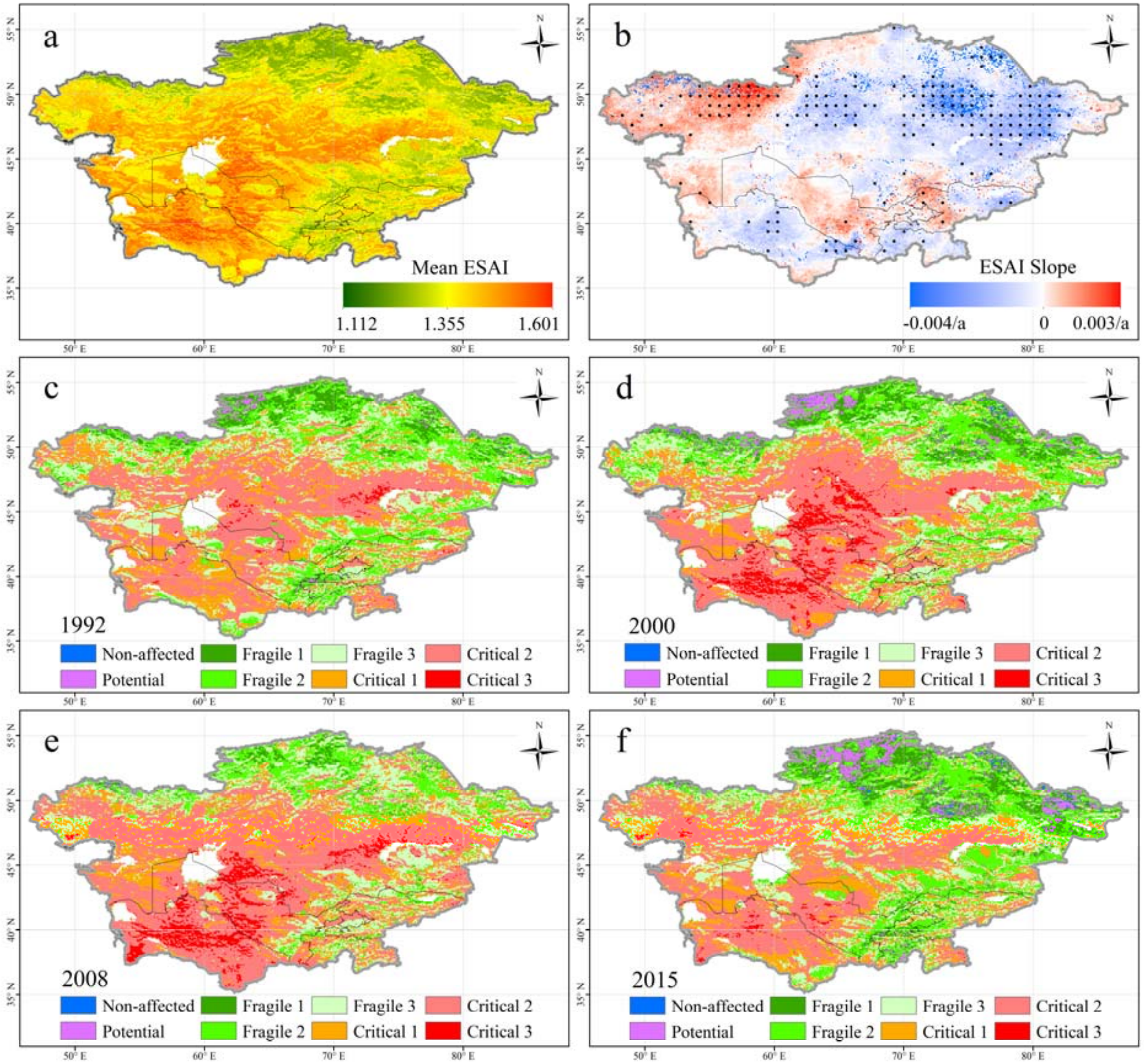
Critical (1.38<ESAI)

Jiang L, Bao A, Jiapaer G, et al. Monitoring land sensitivity to desertification in Central Asia: Convergence or divergence?[J]. Science of The Total Environment, 2018.

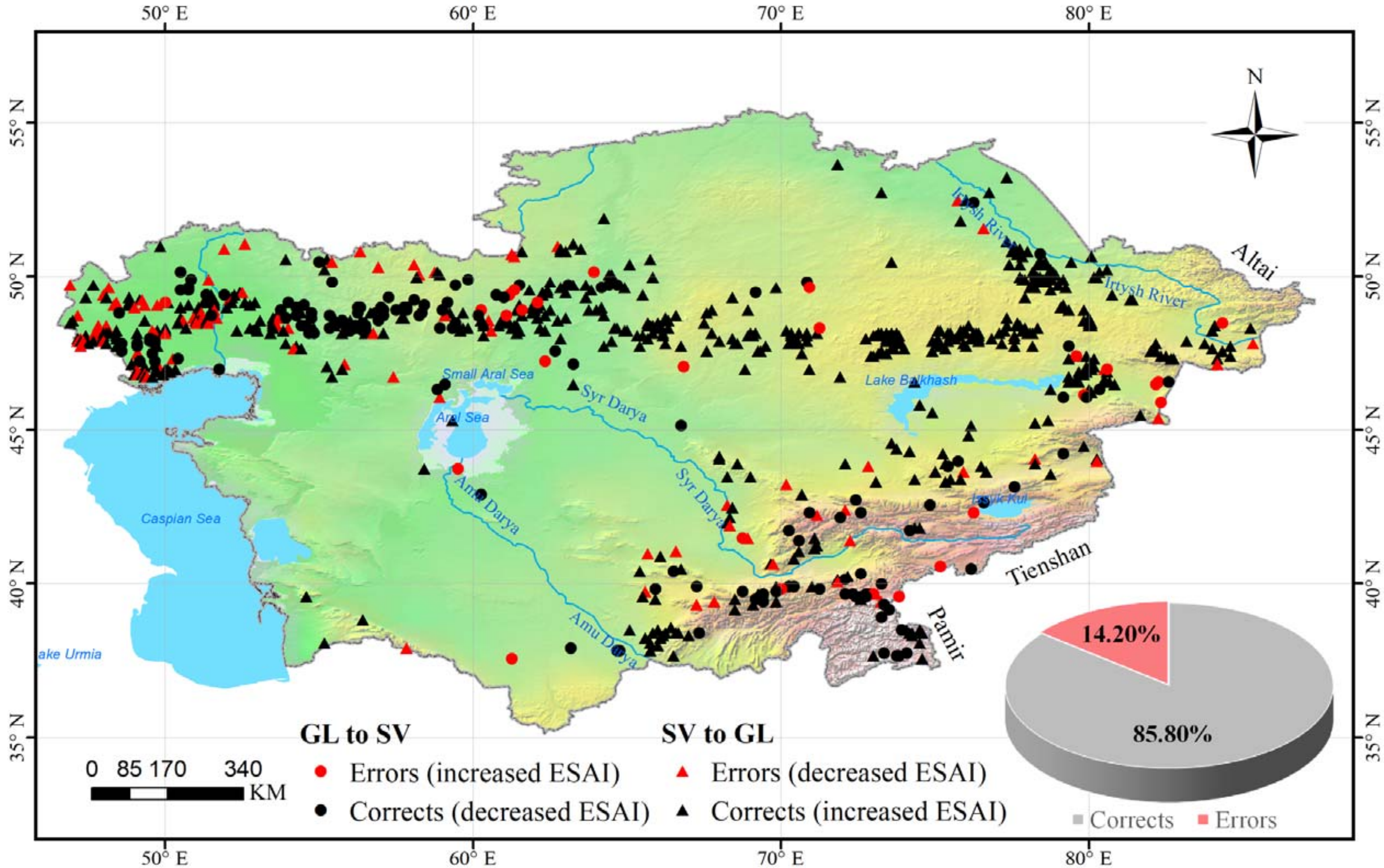
Results

Spatial assessment of ESAI

- MK test: three time intervals (1992-2000, 2000-2008 and 2008-2015)
- The significantly increasing tendency in the Ustyurt Plateau, Uzbekistan and Turkmenistan.
- Central Asia gradually became more sensitive to land degradation in 2008 (than in 1992) and improved after 2008.

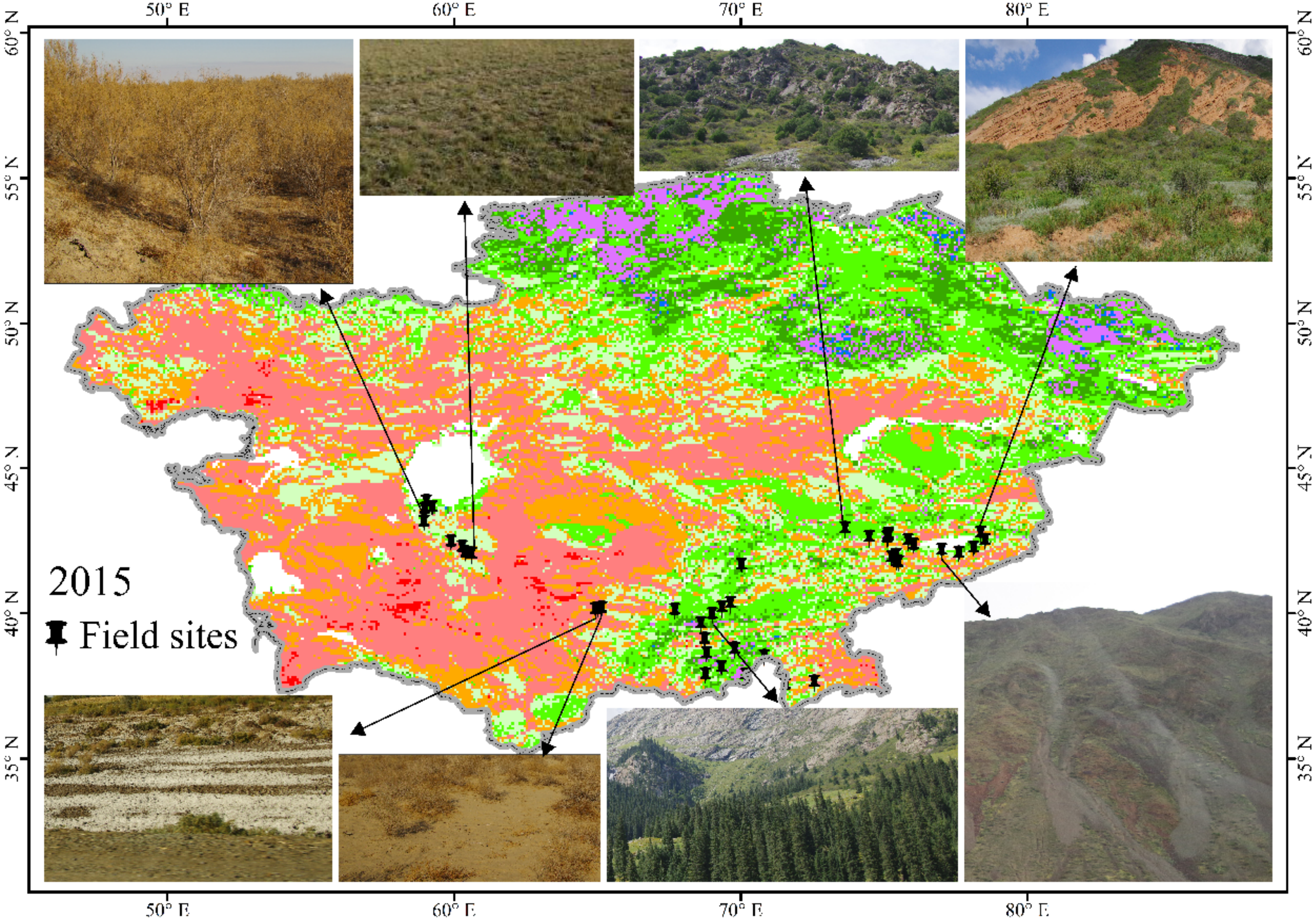


Verification



Spatial distribution of verification points with land use change between sparse vegetation and grasslands. GL: grasslands; SV: sparse vegetation.

Verification



Spatial distribution of the desertification risk of observation sites in 2015.

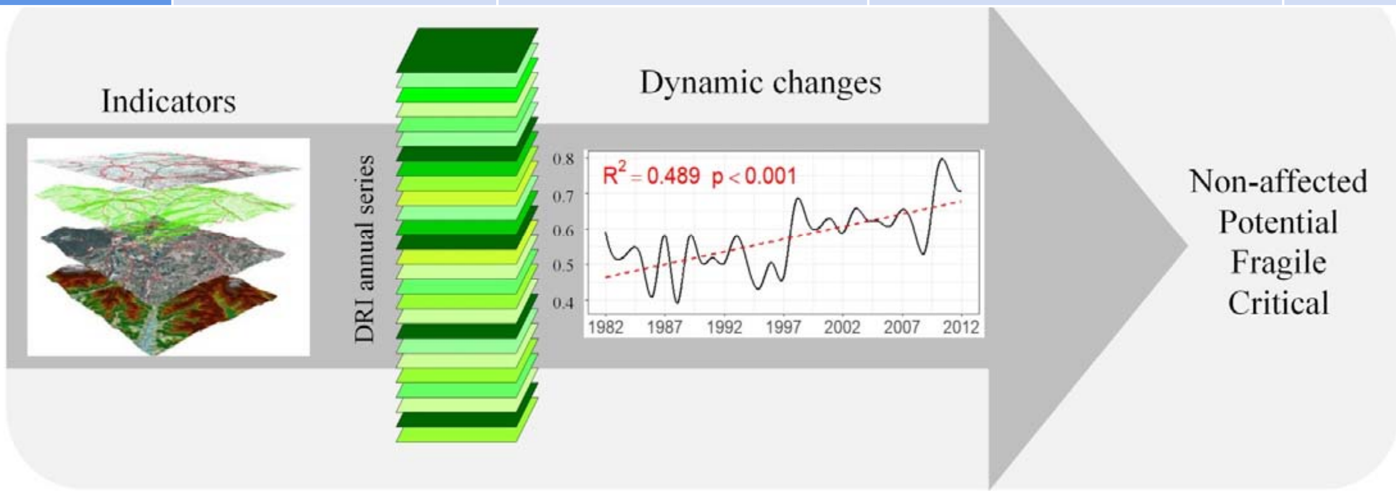
2. Risk Characteristics

2.2 Amu Darya River

Method

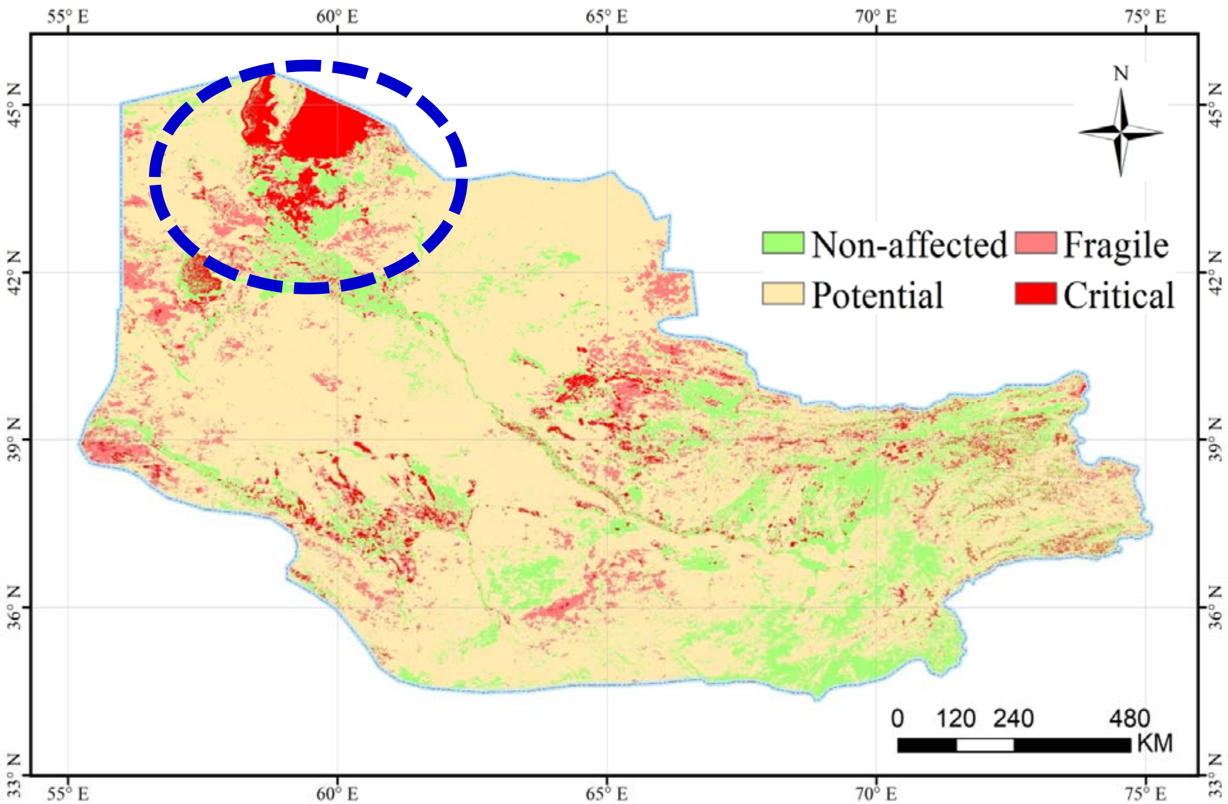
Data: The indicator datasets include NDVI, albedo, Land Surface Temperature (LST), Temperature–Vegetation Dryness Index (TVDI) and Modified Soil-Adjusted Vegetation Index (MSAVI)

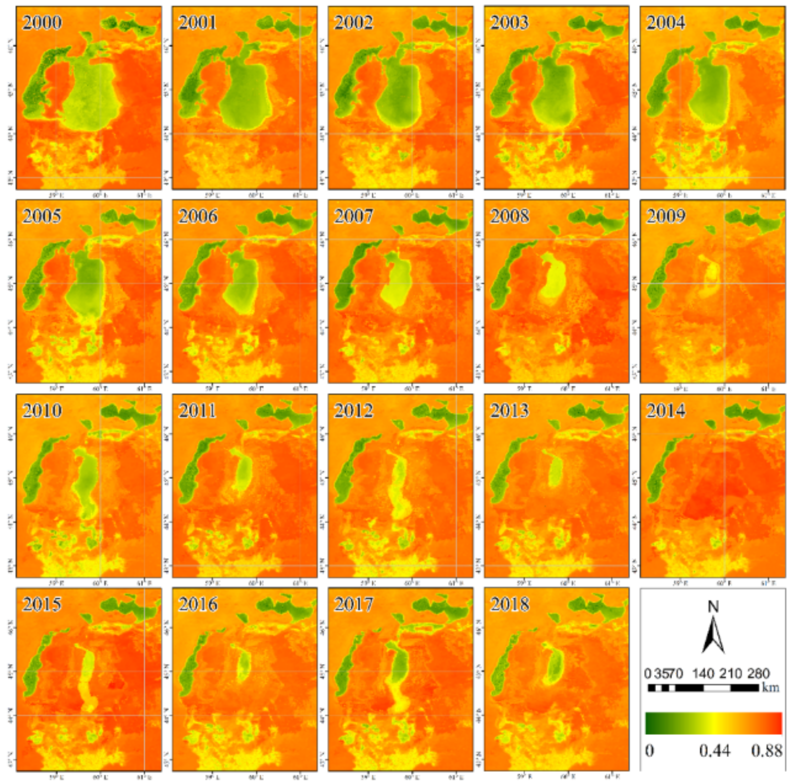
Indicators	Data publisher	Spatial resolution	Temporal resolution	Temporal domain
NDVI	NASA	500m	yearly	2000-2018
Albedo	NASA	500m	yearly	2000-2018
LST	NASA	1000m	yearly	2000-2018
TVDI	CASEarth	500m	yearly	2000-2018
MSAVI	CASEarth	500m	yearly	2000-2018



Results

- Desertification risk in the lower reaches was more serious than that in the upper reaches.
- 71.56% of total land area were determined to be potential desertification risk, whereas 8.89% and 4.28% of total land area were categorized as fragile and critical desertification risk, respectively.
- The critical desertification risk was observed in the Aral Sea and the Amu Darya River Wetland Delta.

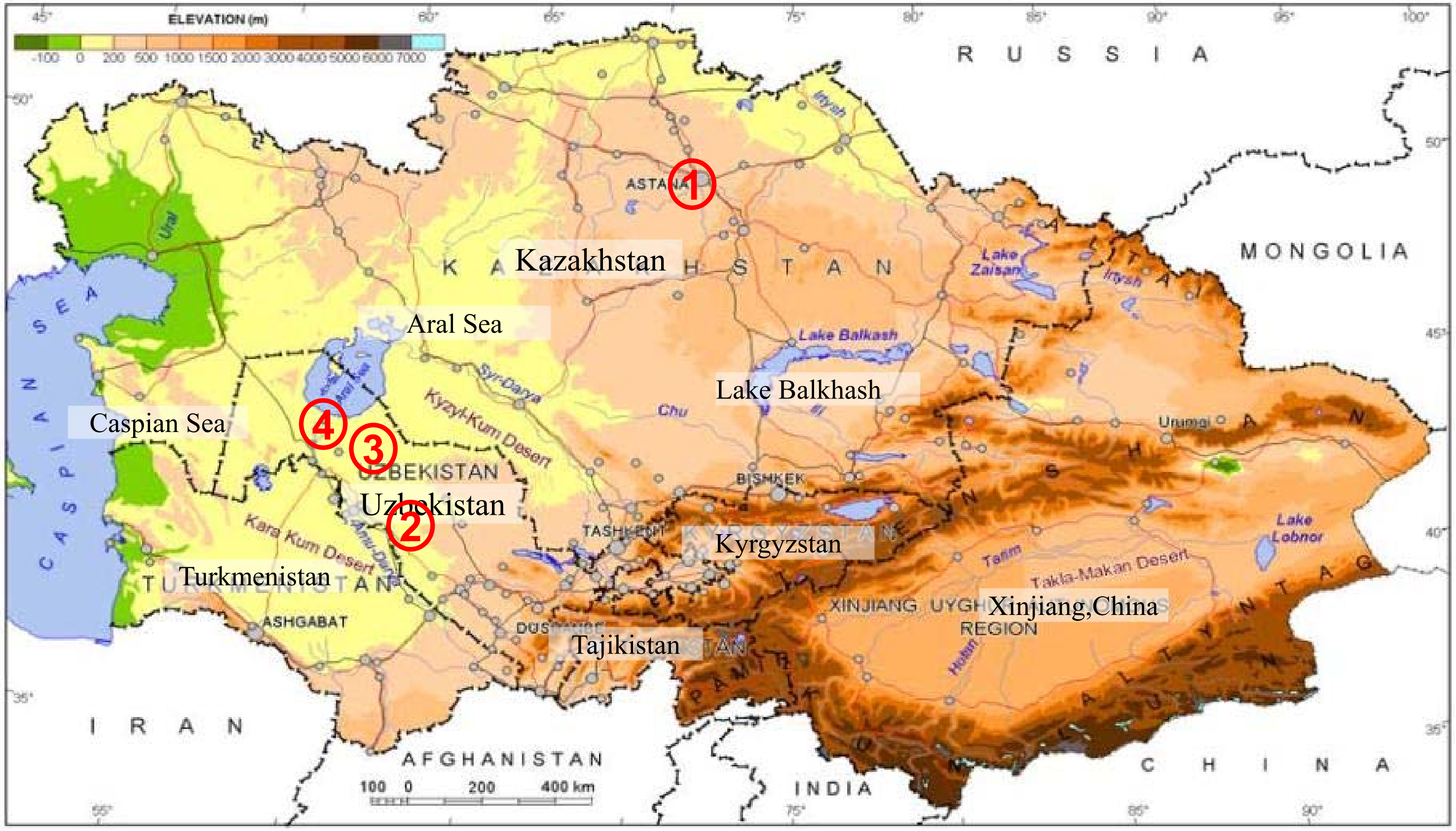




CONTENTS

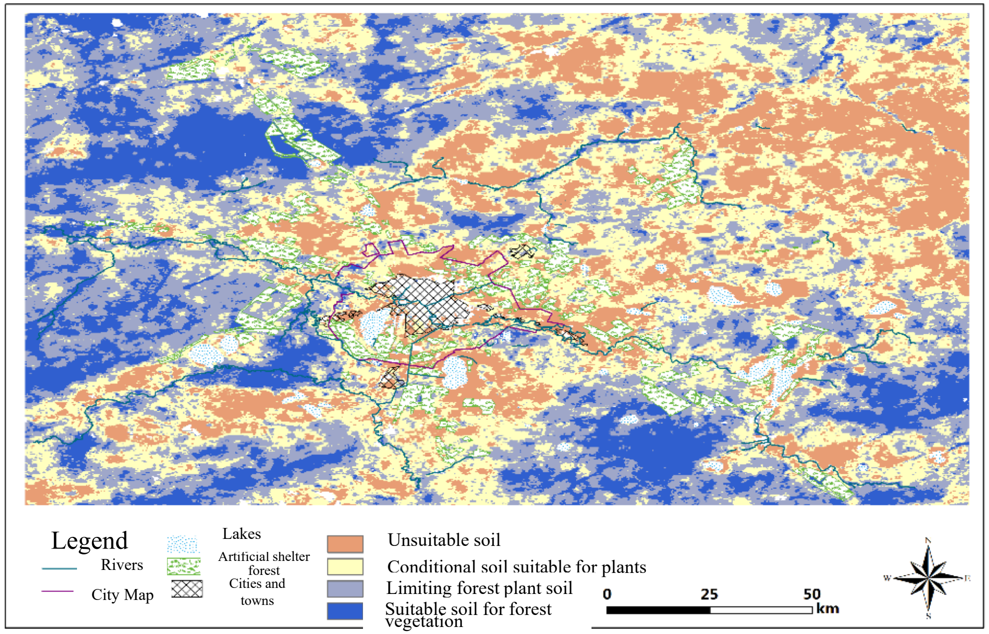
3. Control Pilot Test

1. Optimization technology and experimental demonstration of ecological barrier in Kazakhstan capital circle
2. Sand fixation technology and test demonstration of Sakar desert oil & gas field in Turkmenistan
3. Vegetation restoration and reconstruction technology and experimental demonstration of sandy land in the lower reaches of Amu Darya River Basin
4. Vegetation reconstruction technology and experimental demonstration of saline land around the Aral Sea



1. Optimization technology and experimental demonstration of ecological barrier in Kazakhstan capital circle

The problems Low temperature in winter, snowmelt and ponding in spring, serious soil salinization, unreasonable forest belt configuration and low protection benefit



Technology research & development and integration

- Determination of afforestation obstacle factors list
- Research and development of 11 items of technologies such as micro-terrain reconstruction, soil improvement and shelterbelt optimization
- Research and development of 11 items of technologies such as micro-terrain reconstruction, soil improvement and shelterbelt optimization

Building ecological barrier experimental-demonstration-area

- 12 suitable plants were introduced and screened
- 3 breeding bases have been built with 120,000 seedlings
- Establishing 23 hectares of experimental demonstration area
- Good ecological benefits, attracting the president's attention

Nursery base of Forestry Commission

Experimental base of Severin Agricultural Technology University

Problems in afforestation
Single plant species
High density of forest belt
Premature decline of trees
Poor growth of newly planted plants
Serious salinization In spring
Serious snow-melting and waterlogging in Spring
Long Winter and low temperature
Poor soil texture (gypsum layer, gravel layer)
Poor soil moisture of dry land afforestation

Major consequences
Serious diseases and insect pests in forest land
The growth of trees is hindered
The windbreak effect is weak and the protection period is shortened
The root system of seedlings withered or even died
Low survival rate of trees, poor plant growth and incomplete forest belt
Delaying afforestation time
Freezing injury or death of transferred seedlings
Difficult planting of trees with low survival rate
Difficult planting of trees with low survival rate

Optimization technology formed through R & D
Screening techniques of afforestation plants and breeding techniques of stress resistance
Configuration optimization technology in forest-belt structure and tending & thinning technology
Tending & thinning technology and configuration optimization technology in forest-belt structure
Water retaining agent or mud root dipping technology
Micro-topography improvement technology, soil improvement afforestation technology, selection and breeding technology of afforestation plants
Afforestation technology of micro topography reformation of low-lying land
Cryopreservation technology
Soil improvement & afforestation technology of broken gypsum layer and soil improvement & afforestation technology of gravel slope land
Afforestation technology of snow cover on dry slope land

2. Sand-fixation technology and test demonstration of Sakar desert oil & gas field in Turkmenistan

The problems   strong wind force, large activity of sand surface, serious vegetation damage, and various forms of sand hazards in oil & gas field bases and pipeline roads, which seriously endanger the infrastructure and production safety of oil & gas fields

Experimental demonstration

- Find out the current situation of sand hazard in Sakar oil & gas field
- 5 suitable new sand control materials were selected in the experiment
- Establishing sand hazard control model suitable for desert oil & gas fields
- Preparing the plan for sand control and prevention in desert oil & gas field

Desert type	Harming objects	Harming forms	Control measures
Mobile desert area	Living base	Sand-dune burying, sand-drift accumulation and wind erosion hazard	① Mechanical sand-control ② mechanical sand-fixation ③ vegetation restoration without irrigation④ Construction of shelter forest and greening and beautification in the base
	Production base	Sand-dune burying, sand-drift accumulation and wind erosion hazard	① Mechanical sand-control ② mechanical sand-fixation ③ vegetation restoration without irrigation④ Construction of shelter forest and greening and protection in the base
	single-well for production	Sand-dune burying, sand-drift accumulation and wind erosion hazard	① Mechanical sand-control ② mechanical sand-fixation ③ vegetation restoration without irrigation
	Highway and railway	Sand-dune burying, sand-drift accumulation and wind erosion hazard	① Mechanical sand-control ② mechanical sand-fixation ③ vegetation restoration without irrigation
	Oil and gas pipeline	Wind erosion hazard	① Mechanical sand-control ② vegetation restoration without irrigation
Fixed & semi-fixed desert area	Living base	Sand-drift accumulation and wind erosion hazard	① Mechanical sand-fixation ②vegetation restoration without irrigation③ greening and beautification in shelter forest and in the base
	Production base	Sand-drift accumulation and wind erosion hazard	① Mechanical sand-fixation ②vegetation restoration without irrigation③ greening in shelter forest and in the base
	single-well for production	Sand-drift accumulation and wind erosion hazard	① Mechanical sand-fixation ②vegetation restoration without irrigatio
	Highway and railway	Sand-drift accumulation and wind erosion hazard	① Mechanical sand-fixation ②vegetation restoration without irrigatio
	Oil and gas pipeline	Wind erosion hazard	① Mechanical sand-fixation ②vegetation restoration without irrigatio

3. Vegetation restoration and reconstruction technology and experimental demonstration of sandy land in the lower reaches of Amu Darya River Basin

Problems Increasing drought and overgrazing lead to vegetation degradation, biodiversity loss and sand surface activation

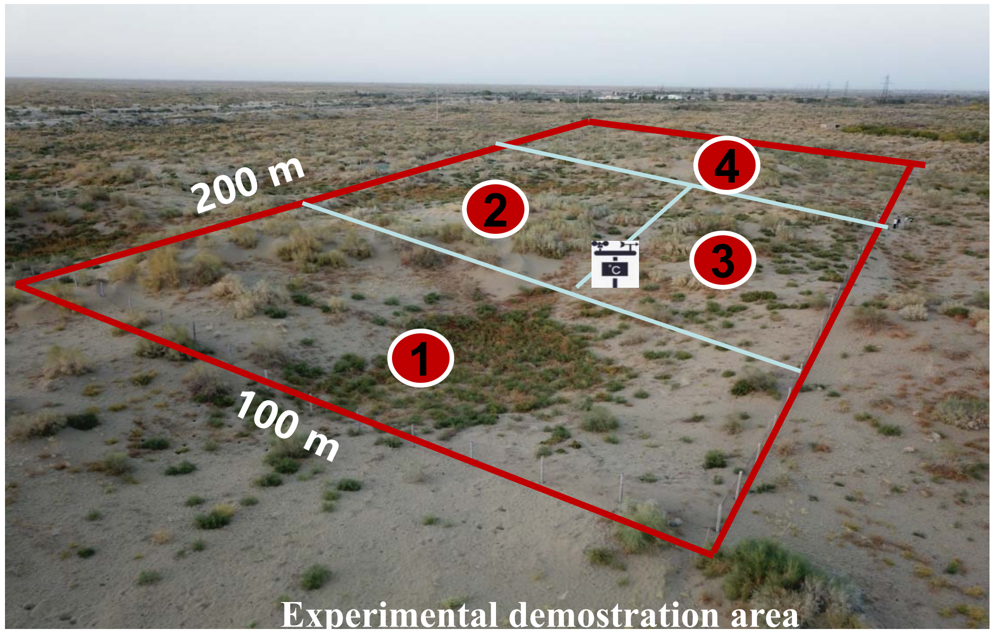
Optimization and restoration&reconstruction of vegetation community structure

- Sand fixation technology of biomass material sand barrier
- Sand fixation technology of biomass material sand barrier
- Artificial colonization technology of biological soil crust
- Vegetation reconstruction technology of biomass tending bowl
- Soil moisture conservation and planting technology of dominant species in vegetation community
- Seeding technology of sand-fixation pioneer UAV

Experimental demonstration

- Experimental area for restoration and reconstruction of plant community
- Experimental area for sowing and restoration of shrub grass seed
- Experimental area for comparison and optimization of sand fixation technology
- Experimental area for closed conservation and natural restoration

Configuration of test areas



Experimental demostration area

4. Vegetation reconstruction technology and experimental demonstration of saline land in the Aral Sea

Problems: the area of salinized land in Amu Darya delta is expanding, the degree of soil salinization is aggravating and the salinity of groundwater is increasing

Planting techniques of salt tolerant plant

- Vegetation restoration technology of drip irrigation with high salinity water
- Cultivation techniques of halophytes by salt water melting and leaching
- Cultivation technology of water collection and moisture conservation in saline alkali sandy land
- Cultivation technology of Suaeda Salsa in the saline land irrigated with saline water
- Cultivation technology of salt tolerant crops irrigated by saline water

Experiments of vegetation reconstruction

- Establishing 20 mu of planting resource nursery of 26 species of halophytes
- Cultivation technology of water collection and moisture conservation in saline alkali sandy land

  Planting and feed test of halophytes
- Planting Simulation Experiment of Suaeda salsa (Karamay)

CONTENTS

4. Conclusion

- The risk of desertification is high in the southern plain area of Central Asia and low in the northern and mountainous areas
- From 1992 to 2008, the high-risk area of desertification in Central Asia increased by 13.66%, and the spatial divergence of desertification was mainly caused by human activities or the decrease of precipitation;

  From 2008 to 2015, the high-risk area decreased by 19.70%, and the spatial convergence was mainly due to the increase of precipitation
- From 2000 to 2018, the potential desertification risk area of Amu Darya River Basin accounted for 71.58%, low risk accounted for 8.89% and high risk accounted for 4.28%
- The risk of desertification in the middle and lower reaches of Amu Darya River is high and the high risk of desertification in Amu Darya delta is concentrated in distribution
- The risk of desertification in the Aral Sea Basin and its surrounding areas is high and the risk of desertification in the eastern part of the Aral Sea is the highest
- Key technologies for desertification control in Central Asia have been formed and 4 experimental demonstration areas have been established


THANK YOU !