Geodatabase and Diagnostic Atlas: Kashkadarya Province, Uzbekistan

Zafar Gafurov, Sarvarbek Eltazarov, Bekzod Akramov, Kakhramon Djumaboev, Oyture Anarbekov and Umida Solieva

IWMI International Water Management Institute

Ministry of Agriculture and Water Resources in Uzbekistan

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The International Water Management Institute (IWMI) is a non-profit, scientific research organization focusing on the sustainable use of water and land resources in developing countries. IWMI works in partnership with governments, civil society and the private sector to develop scalable agricultural water management solutions that have a real impact on poverty reduction, food security and ecosystem health. Headquartered in Colombo, Sri Lanka, with provinceal offices across Asia and Africa, IWMI is a CGIAR Research Center and leads the CGIAR Research Program on Water, Land and Ecosystems (WLE).

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/ GIS / remote sensing / river basins / digital technology / maps / simulation models / satellite imagery / urban population / urban areas / rural population / rural areas / population density / irrigation systems / irrigation water / water resources / water storage / water use efficiency / canals / drainage systems / pumps / lakes / reservoir storage / watersheds / streams / transportation / groundwater / soil types / vegetation / ecosystems / climate change / infrastructure / Uzbekistan /

Please send inquiries and comments to IWMI-Publications@cgiar.org

Acknowledgments

The 'Geodatabase and Diagnostic Atlas: Kashkadarya Province, Uzbekistan' is based on data and information generated and collected data within the framework of the USAID PEER Cycle 4 project 'Mitigating the competition for water in Amudarya River basin, Central Asia by improving water use efficiency'. Also data obtained from published and grey literature as well as spatial analyses carried out using publicly available sources. The authors would like to thank project partners in both Uzbekistan for their input and feedback to content of the atlas. Additionally, the authors would like to acknowledge Shovkat Khodjaev for his technical assistance.

Project

The geodatabase and digital diagnostic atlas were generated within the framework of the "Mitigating the competition for water in Amudarya River basin, Central Asia by improving water use efficiency" project being implemented by the International Water Management Institute (IWMI) in collaboration with USDA-ARS, UZGIP (Uzbekistan), and Sogd Water Authority (Tajikistan). Since 2015, the project has been supporting the two Central Asian states (Uzbekistan and Tajikistan) to evaluate the potential for improving water-use efficiency by mitigating measures for water and energy use in the Amu Darya and Syr Darya river basins.

For further details about the project, visit: http://sites.nationalacademies.org/PGA/PEER/PEERscience/PGA_168055

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The United States Agency for International Development (USAID)
Partnerships for Enhanced Engagement in Research (PEER) Program

Part I: Geodatabase Overview

Introduction

The geodatabase and digital diagnostic atlas were generated within the framework of USAID PEER Cycle 4 project "Mitigating the competition for water in Amudarya River basin, Central Asia by improving water use efficiency" being implemented by the International Water Management Institute (IWMI) in collaboration with USDA-ARS, UZGIP (Uzbekistan) and Sogd Water Authority (Tajikistan). Since 2015, the project has been supporting Uzbekistan and Tajikistan to evaluate the potential for improving water-use efficiency by mitigating measures for water and energy use in the Amu Darya and Syr Darya river basins.

A strong and permanent element of the project is data generation in water-related state aspects, with a view to specifically developing a geodatabase and digital diagnostic atlas using open source data. The geodatabase consists of various input data, which were obtained from open domains of several government and non-government organizations, and present the data through visually appealing maps and other visually informative forms (i.e., charts, infographics, etc.) to show the spatial and temporal distribution of water and land resources and the way they are used.

Data Accuracy and Reliability

The geodatabase was created using open source GIS, Remote Sensing and local analogue information, some of which has been published by world renowned organizations and used in public projects and scientific research certified by international agencies.

Availability and Accessibility

The geodatabase can be obtained in digital form for use by external parties with the approval of the International Water Management Institute. In order to obtain the geodatabase please contact with the office in the province.

Software Employed

This geodatabase and the associated maps were created on a computer machine running Windows 10 Professional and using ArcGIS 10.5, QGIS, Google Earth Engine. End users should download the package that is most appropriate for the version of ArcGIS software that they are using. It is important to note that ArcGIS is not only required to make use of the map package and the associated geodatabase.

Data Sources

International Water Management Institute (IWMI)

National Aeronautics and Space Administration - Land Data Products and Services (NASA LP DAAC)

International Center for Agricultural Research in the Dry Areas (ICARDA)

The State Committee of The Republic of Uzbekistan on Statistics (UZSTAT)

European Space Agency (ESA)

World Climate Research Programme (WCRP),
Coupled Model Intercomparison Project (CMIP)

Ministry of Agriculture and Water Resources in Uzbekistan (MAWR)

“UzGIP” Design and Research Institute

Map Projection and Coordinate System

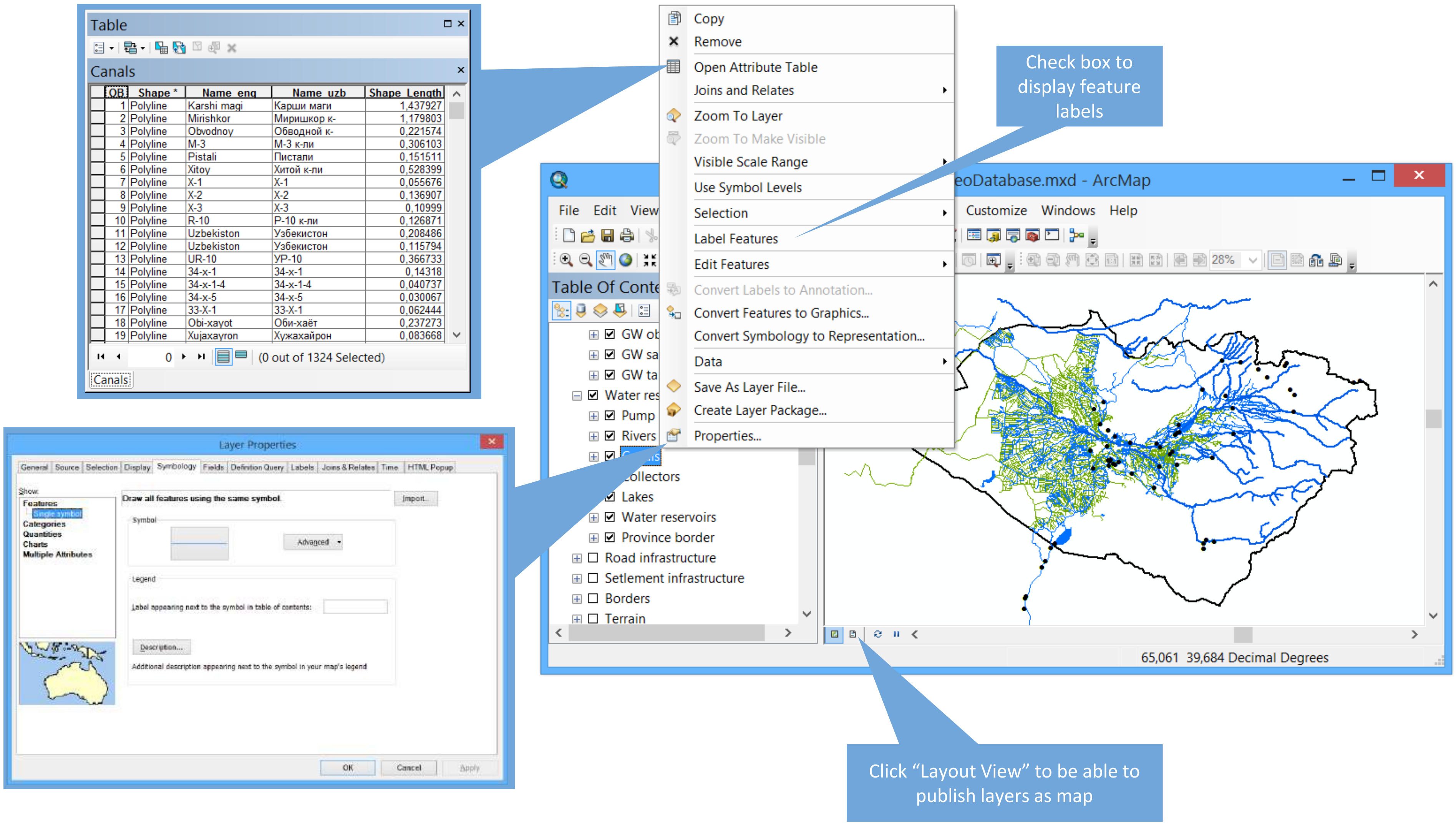
Map projections describe the techniques that represent the Earth’s curved surface on a flat map. Coordinate systems describe the grid referenced and measurement units, effectively translating the map projection. In order to overlay the GIS layers on each other, a single data frame is required. In the geodatabase, the layers are projected into a common coordinate system WG 1984 World Mercator.

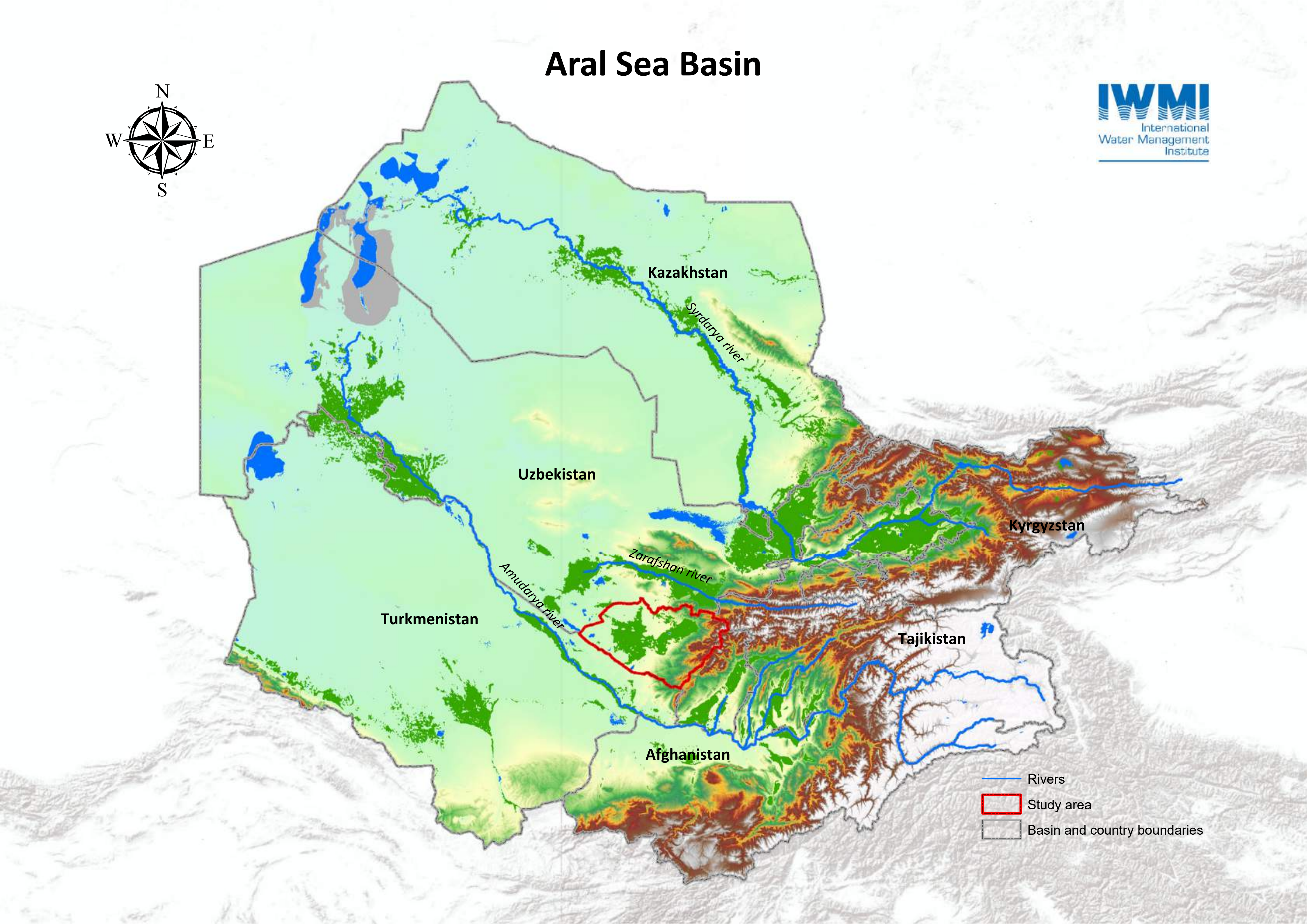
Objective and Recommendation for Use

The main objective of the geodatabase development was to convert raw data into maps, charts, and infographics for visual interpretation of water and land resources in the province in a consolidated form. The authors hope that it can be used as a tool to inform management practices and support decision making at the local, national, and provinceal levels.

Part II. ArcMap Users

ArcMap users may download and use the full geodatabase (.gdb) file and associated .mxd file. This option provides the highest functionality for users interested in carrying out spatial analyses processes. The .mxd document is available for ArcMap 10.5. To ensure you download the correct .mxd file, first verify your ArcMap version. To do this, go to Help > About ArcMap. Then, open the .mxd file to access the geodatabase.




Aral Sea Basin
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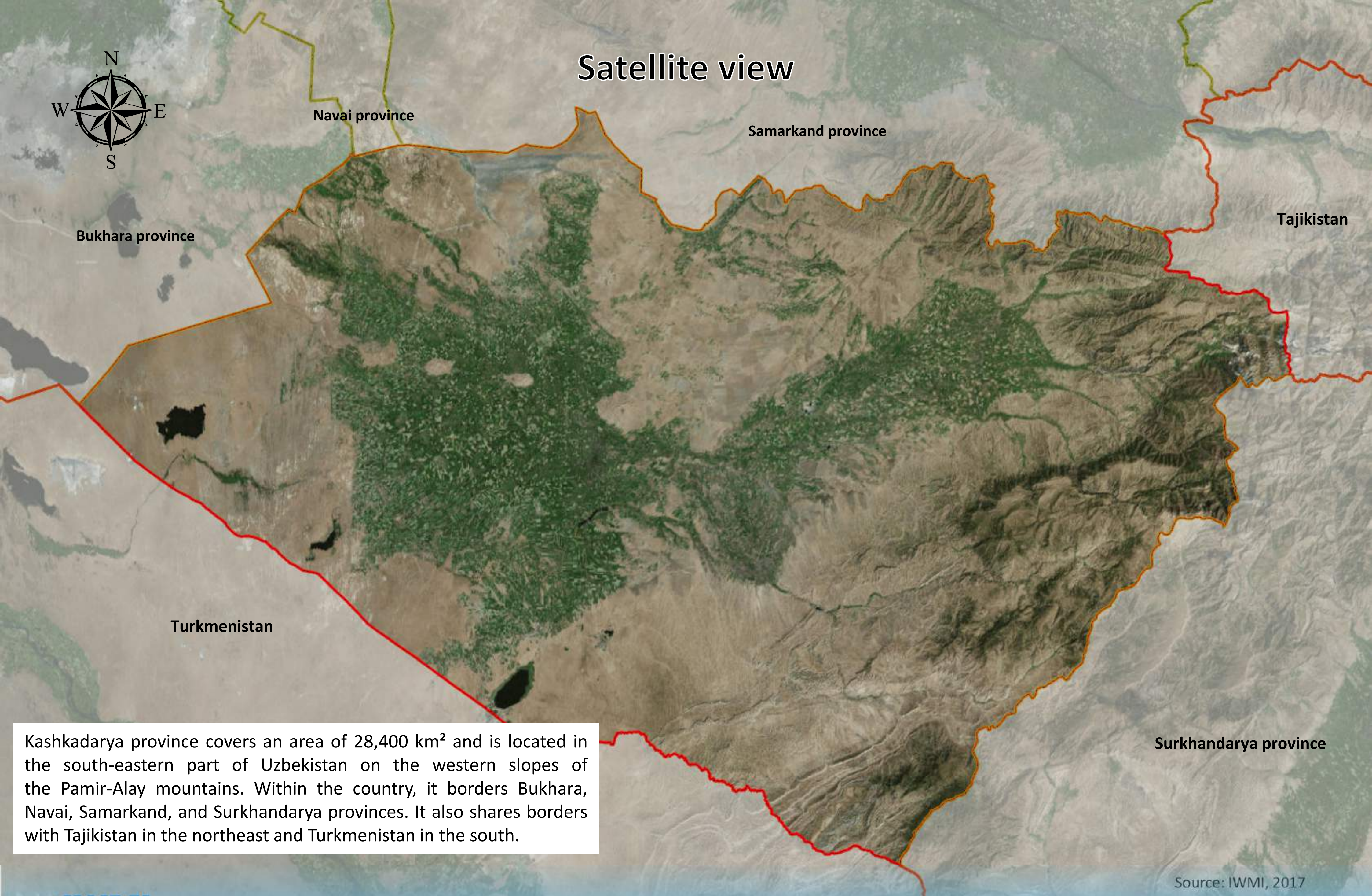
IWMI
International
Water Management
Institute
Kazakhstan
Syrdarya river
Uzbekistan
Kyrgyzstan
Zarafshan river
Amudarya river
Turkmenistan
Tajikistan
Afghanistan
Rivers
Study area
Basin and country boundaries

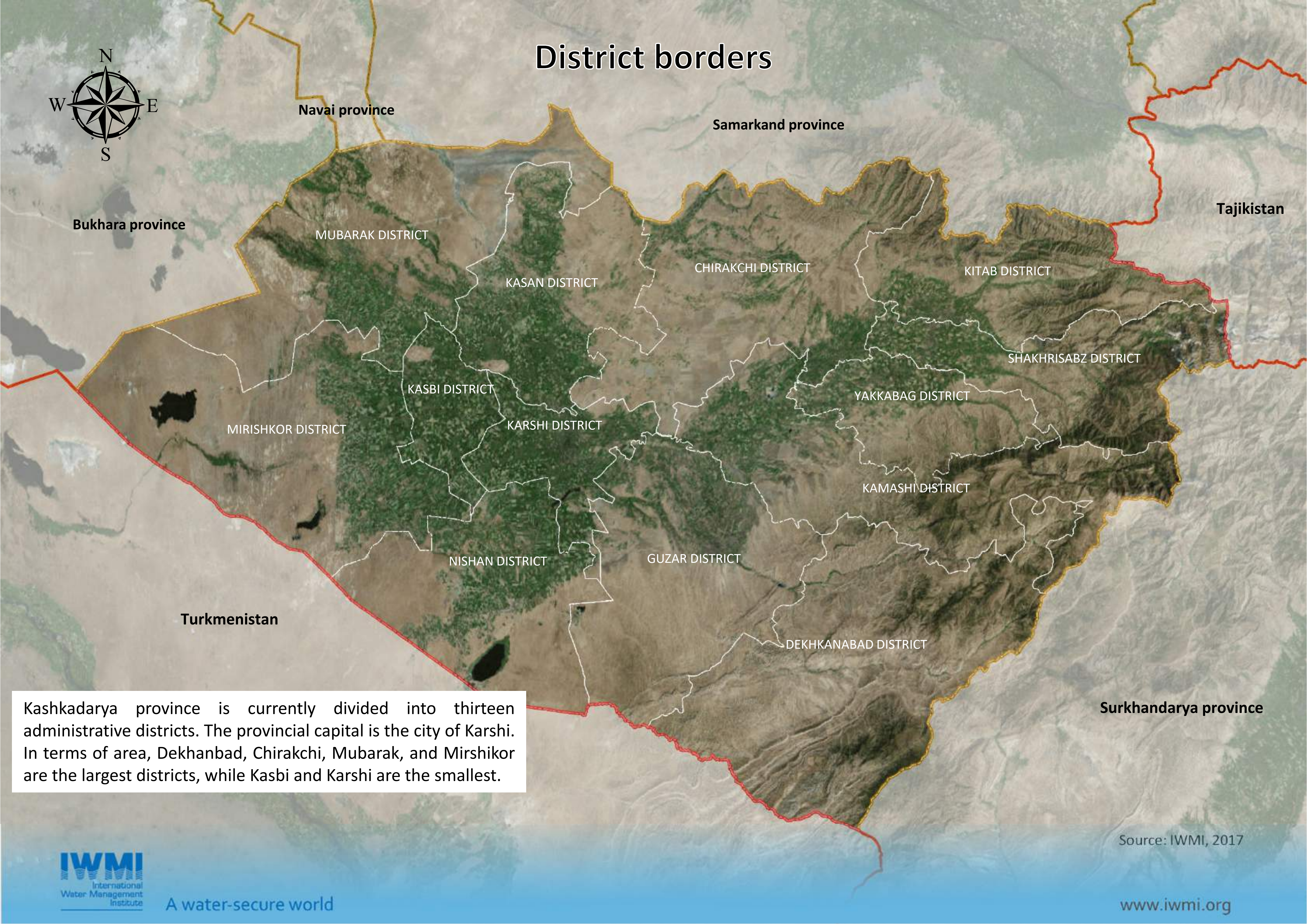
Satellite view



Kashkadarya province covers an area of 28,400 km² and is located in the south-eastern part of Uzbekistan on the western slopes of the Pamir-Alay mountains. Within the country, it borders Bukhara, Navai, Samarkand, and Surkhandarya provinces. It also shares borders with Tajikistan in the northeast and Turkmenistan in the south.

Source: IWMI, 2017

District borders



Kashkadarya province is currently divided into thirteen administrative districts. The provincial capital is the city of Karshi. In terms of area, Dekhanbad, Chirakchi, Mubarak, and Mirshikor are the largest districts, while Kasbi and Karshi are the smallest.

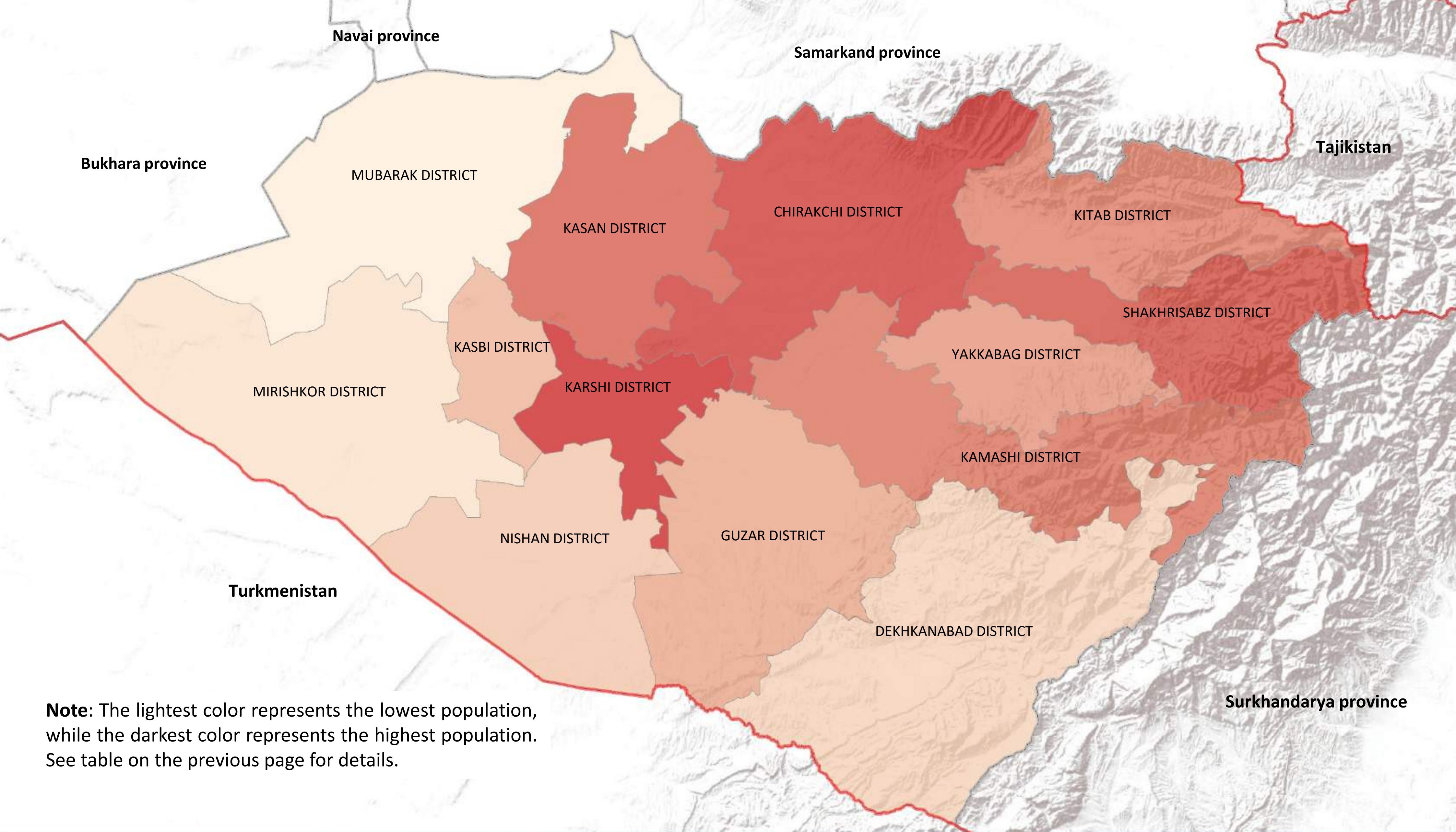
District wise population

	District	Total population	Male	Female
	Mubarak	80700	40700	40000
	Mirishkor	111500	56900	54600
	Dekhkanabad	136100	68400	67700
	Nishan	139100	69500	69600
	Kasbi	182500	92600	90000
	Guzar	190700	96400	94200
	Kamashi	251800	126800	124800
	Yakkabag	244600	123600	121000
	Kitab	247000	125400	121600
	Kasan	263600	133200	130400
	Shakhrisabz	339900	172600	167300
	Chirakchi	374000	189200	185000
	Karshi	491300	244700	246600
	Total	**3052800**	**1540000**	**1512800**

Source: UZSTAT, 2016

- As of 2016, the population of Kashkadarya province was estimated to be about 3,052,800. In Uzbekistan, it is the third most populous province after Samarkand and Fergana provinces.
- Men make up 50.4 percent of the total population, while women make up 49.6 percent of the total population.
- Despite being one of the smaller districts in terms of area, Karshi district has the highest population with 491,300 people (making up 16.1 percent of the total population). Chirakchi and Shakhrisabz are the next most populous districts with populations of 374,000 and 339,900 respectively. Mubarak has the lowest population with 80,700 people, meaning it has a pretty low population density given its large area.

Population map



Note: The lightest color represents the lowest population, while the darkest color represents the highest population. See table on the previous page for details.

Source: UZSTAT, 2016

District wise urban population

	District	Total urban population	Male	Female
	Dekhkanabad	25800	13100	12700
	Mirishkor	41800	21400	20400
	Guzar	44800	22800	22000
	Kamashi	59600	30800	28800
	Mubarak	63900	32200	31700
	Kasbi	70100	35400	34700
	Yakkabag	79100	40200	38900
	Nishan	84500	42200	42300
	Chirakchi	89900	45800	44100
	Kitab	92700	47300	45400
	Kasan	131300	69500	67800
	Shakhrisabz	175700	88900	86800
	Karshi	346400	173100	173300
	Total	**1311600**	**662700**	**648900**

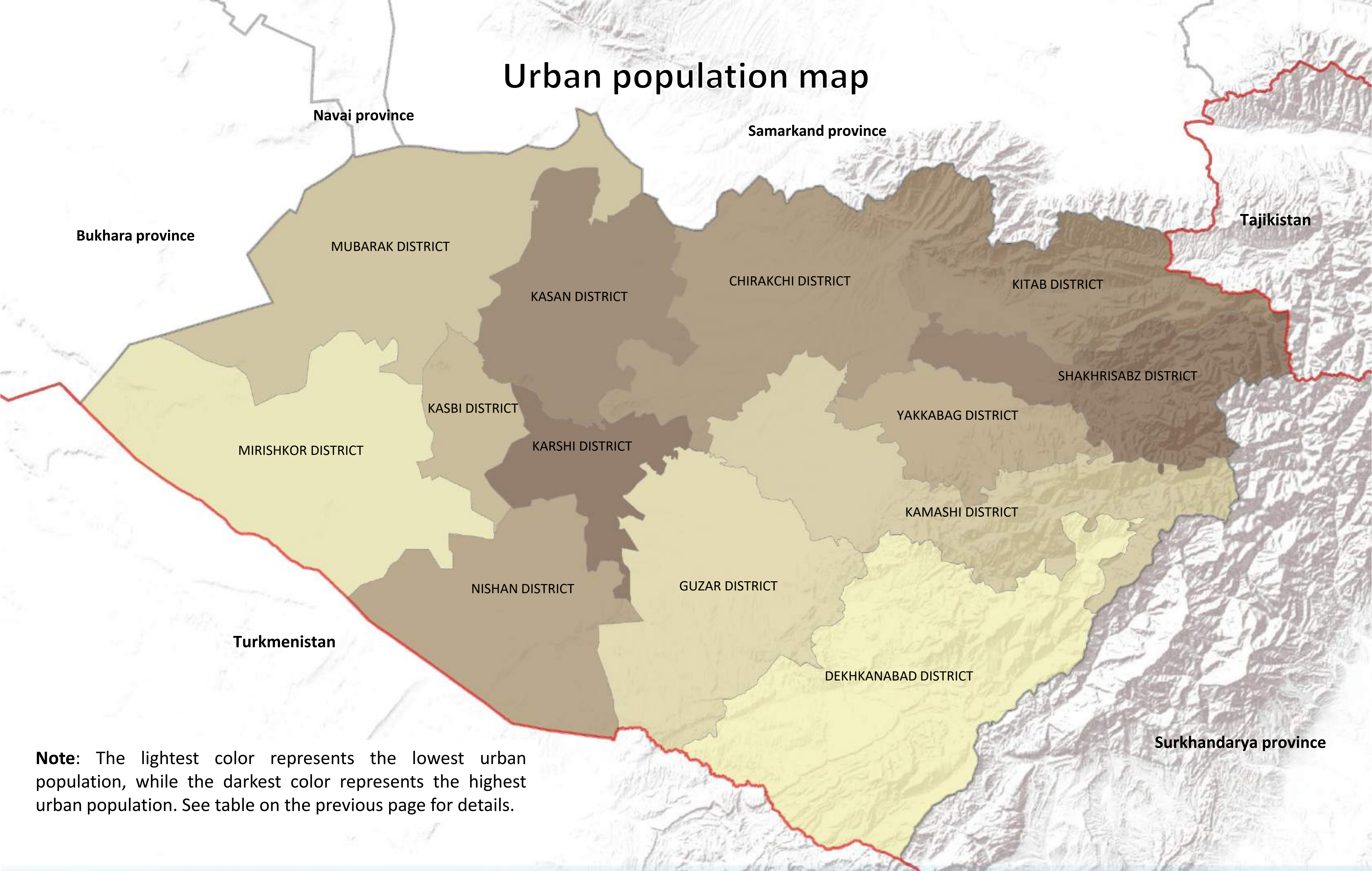
Source: UZSTAT, 2016

- As of 2016, the urban population of Kashkadarya province was estimated to be about 1,311,600, making up about 43 percent of the total population in the province.

- Men make up 50.5 percent of the total urban population, while women make up 49.5 percent of the total urban population.

- Karshi district has the highest urban population in the province with 346,400 people, which means that more than 70 percent of the district's total population lives in urban areas. Shakhrisabz (175,700) and Kasan (131,300) districts have the next two highest urban populations in the province. Dekhanabad has the lowest urban population with 25,800 people, meaning that only about 19 percent of the district's total population lives in urban areas.

Urban population map



Note: The lightest color represents the lowest urban population, while the darkest color represents the highest urban population. See table on the previous page for details.

Source: UZSTAT, 2016

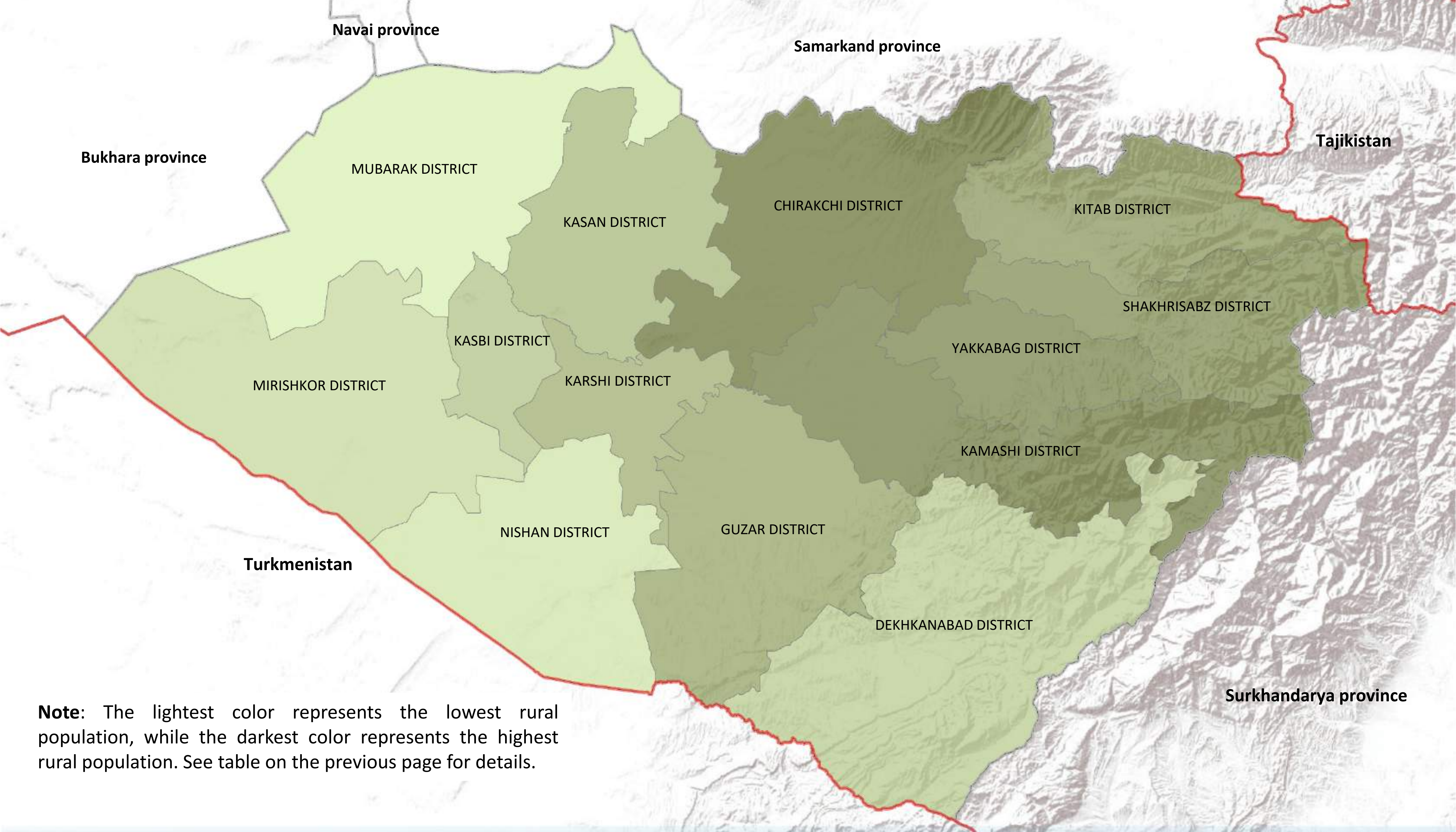
District wise rural population

	District	Total rural population	Male rural population	Female rural population
	Mubarak	16800	8600	8200
	Nishan	54600	27300	27300
	Mirishkor	69700	35500	34200
	Dekhkanabad	110300	55200	55100
	Kasbi	112400	57200	55200
	Kasan	126300	63700	62600
	Karshi	144900	71600	73300
	Guzar	145900	73600	72300
	Kitab	154300	78100	76200
	Shakhrisabz	164200	83800	80400
	Yakkabag	165500	83400	82100
	Kamashi	192200	96100	96100
	Chirakchi	284100	143400	140700
	Total	**1741200**	**877500**	**863700**

Source: UZSTAT, 2016

- As of 2016, the rural population of Kashkadarya province was estimated to be about 1,741,200, making up about 57 percent of the total population in the province.
- Men make up 50.4 percent of the total rural population, while women make up 49.6 percent of the total rural population.
- Chirakchi district has the highest rural population in the province with 284,100 people, which means that about 76 percent of the district's total population lives in rural areas. Kamashi , Yakkabag, Shakhrisabz, and Kitab districts also have considerable rural populations. Mubarak has the lowest rural population with 16,800 people, meaning that only about 21 percent of the district's total population lives in rural areas.

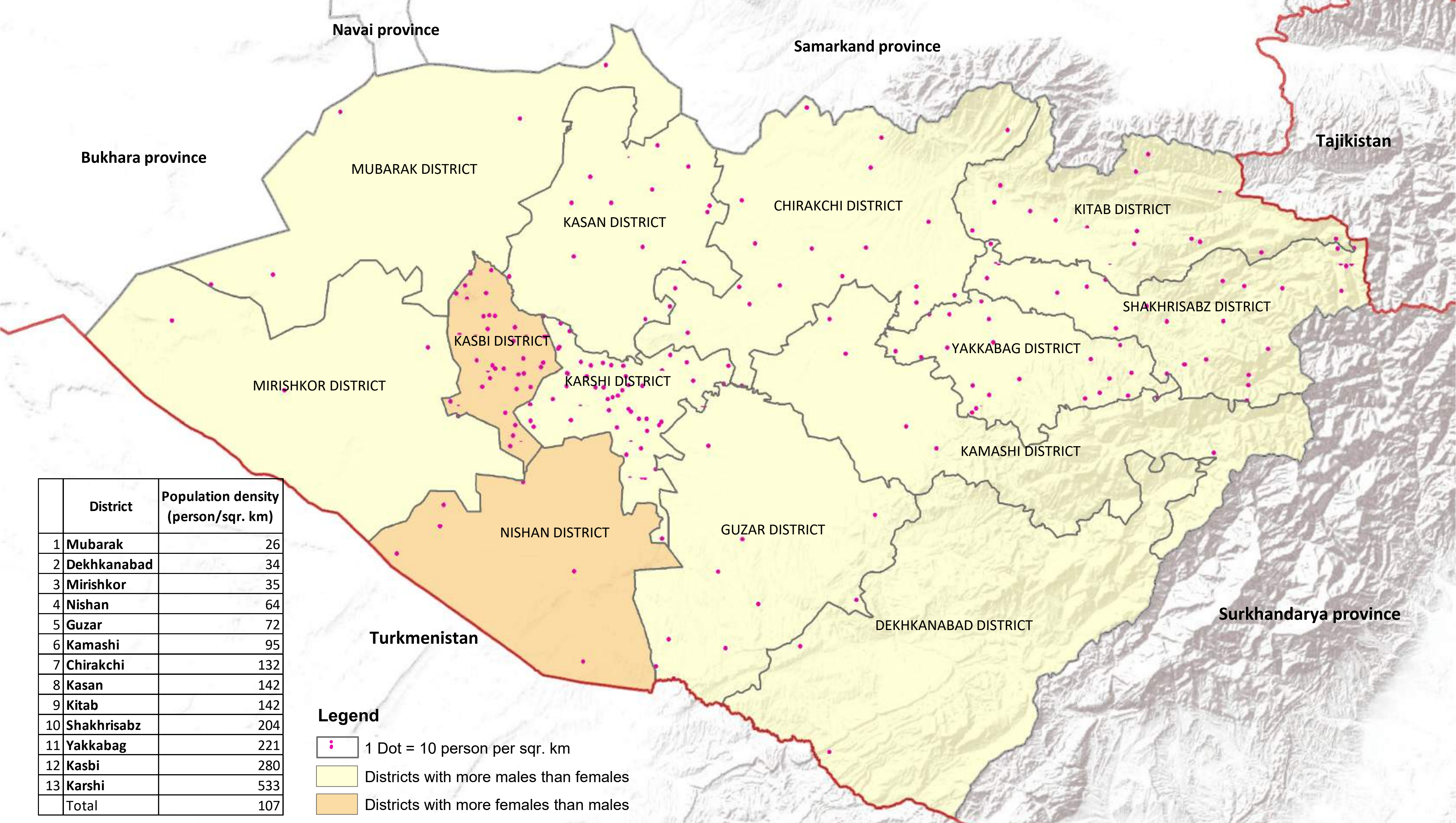
Rural population map



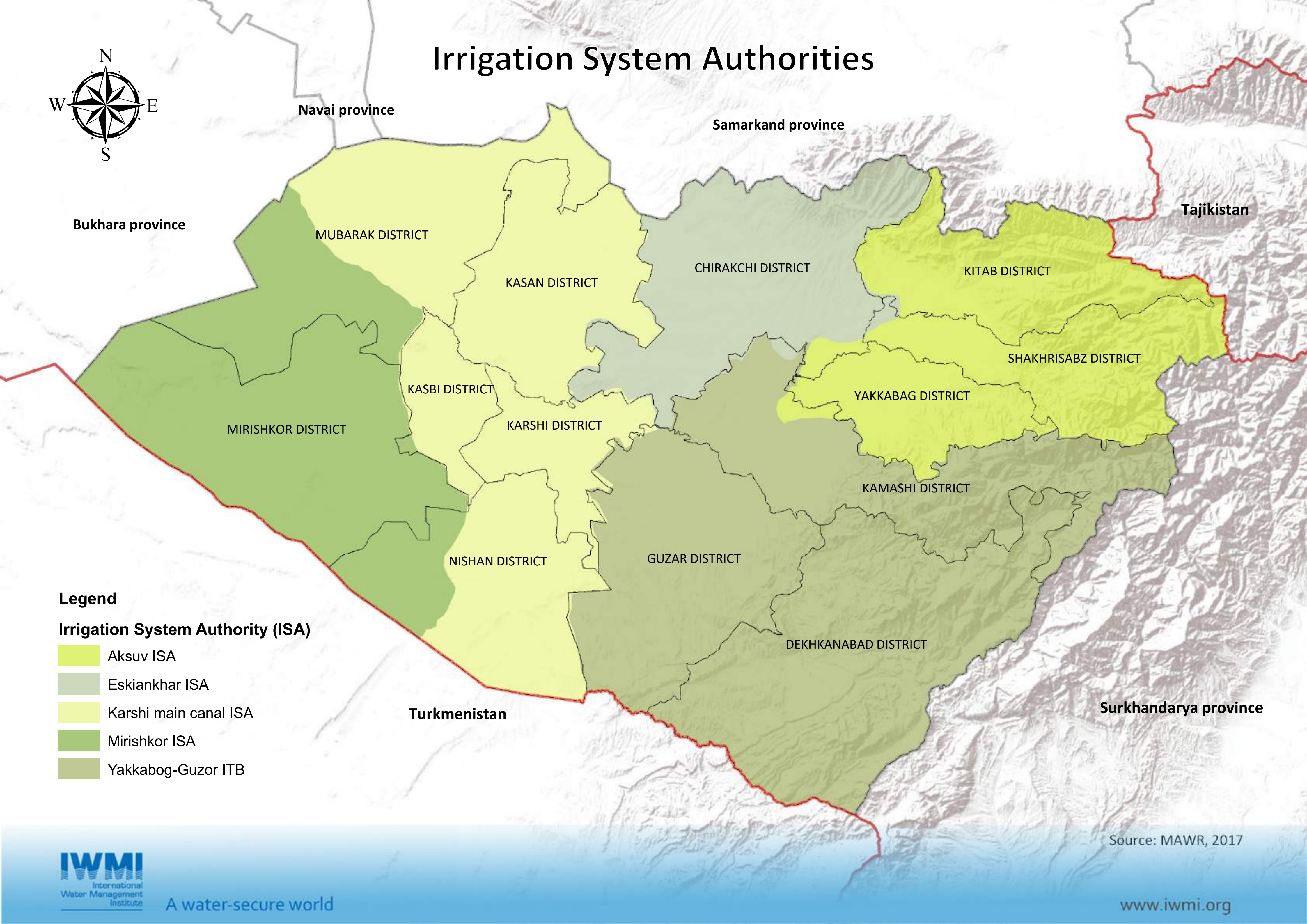
Note: The lightest color represents the lowest rural population, while the darkest color represents the highest rural population. See table on the previous page for details.

Source: UZSTAT, 2016

Population density



	District	Population density (person/sqr. km)
1	**Mubarak**	26
2	**Dekhkanabad**	34
3	**Mirishkor**	35
4	**Nishan**	64
5	**Guzar**	72
6	**Kamashi**	95
7	**Chirakchi**	132
8	**Kasan**	142
9	**Kitab**	142
10	**Shakhrisabz**	204
11	**Yakkabag**	221
12	**Kasbi**	280
13	**Karshi**	533
	Total	107


Irrigation System Authorities
N
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Navai province
Samarkand province
Bukhara province
Tajikistan
MUBARAK DISTRICT
KASAN DISTRICT
CHIRAKCHI DISTRICT
KITAB DISTRICT
SHAKHRISABZ DISTRICT
YAKKABAG DISTRICT
KASBI DISTRICT
KARSHI DISTRICT
MIRISHKOR DISTRICT
KAMASHI DISTRICT
GUZAR DISTRICT
NISHAN DISTRICT
DEKHKANABAD DISTRICT
Turkmenistan
Surkhandarya province
Legend
Irrigation System Authority (ISA)
Aksuv ISA
Eskiankhar ISA
Karshi main canal ISA
Mirishkor ISA
Yakkabog-Guzor ITB
Source: MAWR, 2017
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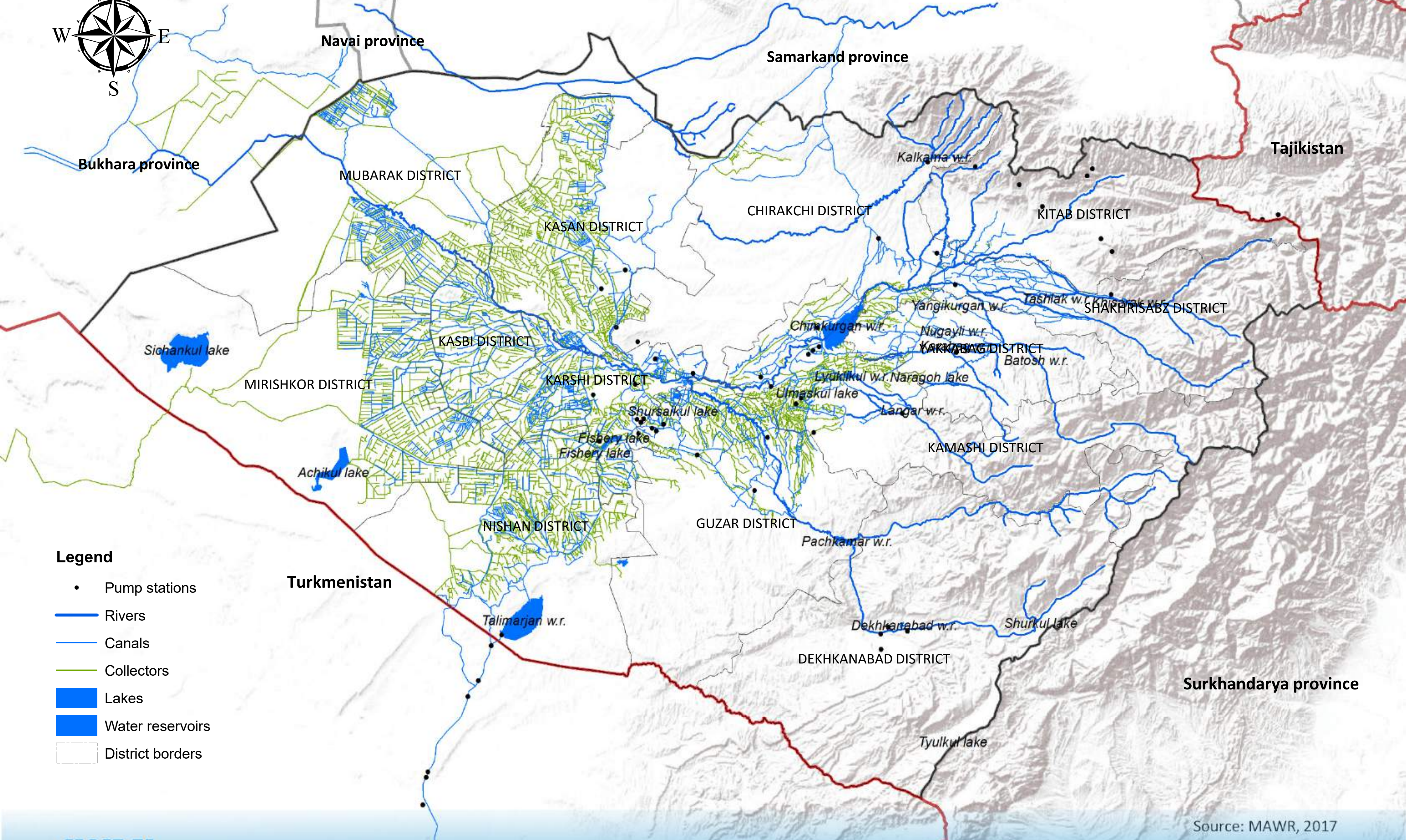
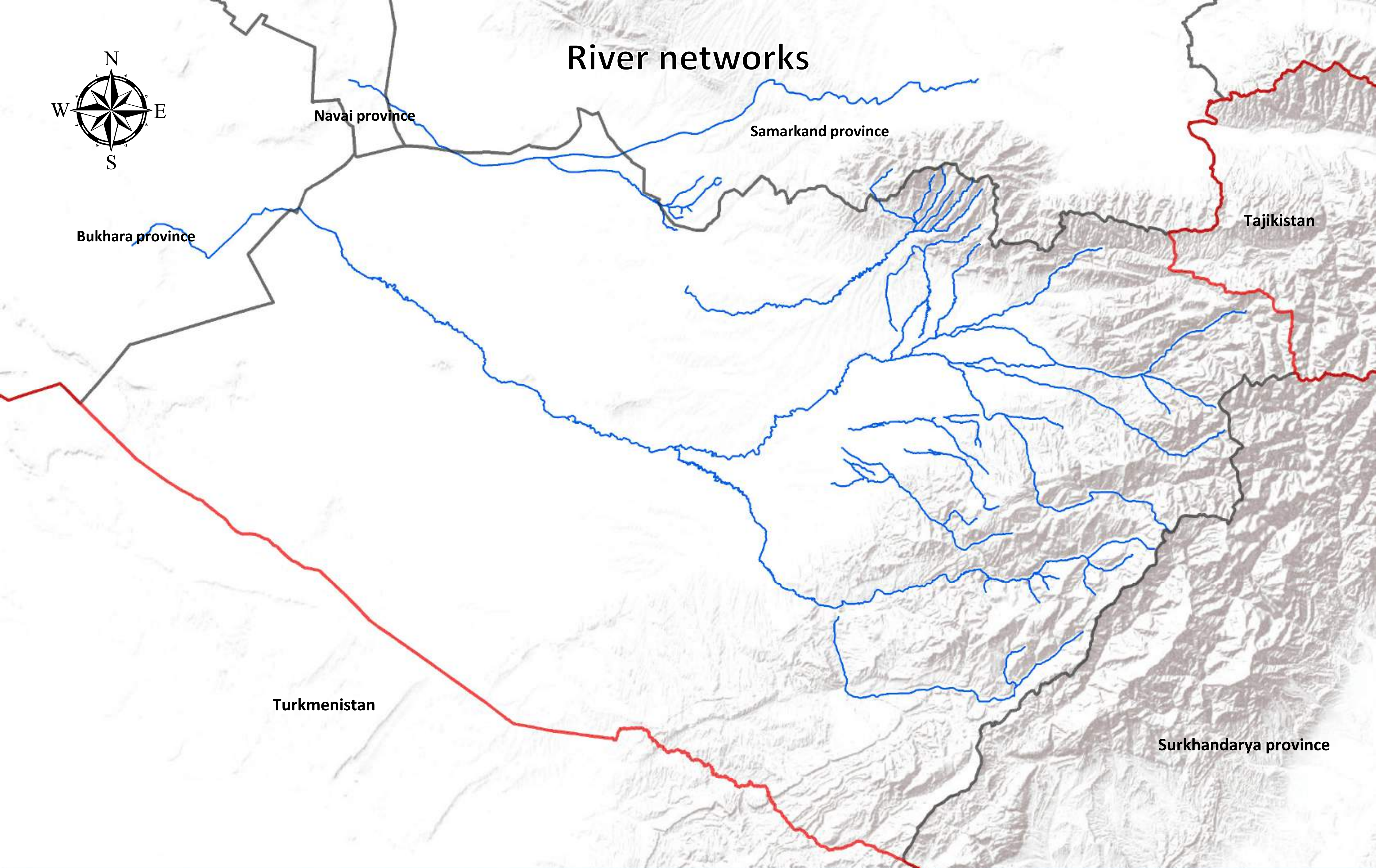
Water resources and irrigation infrastructures

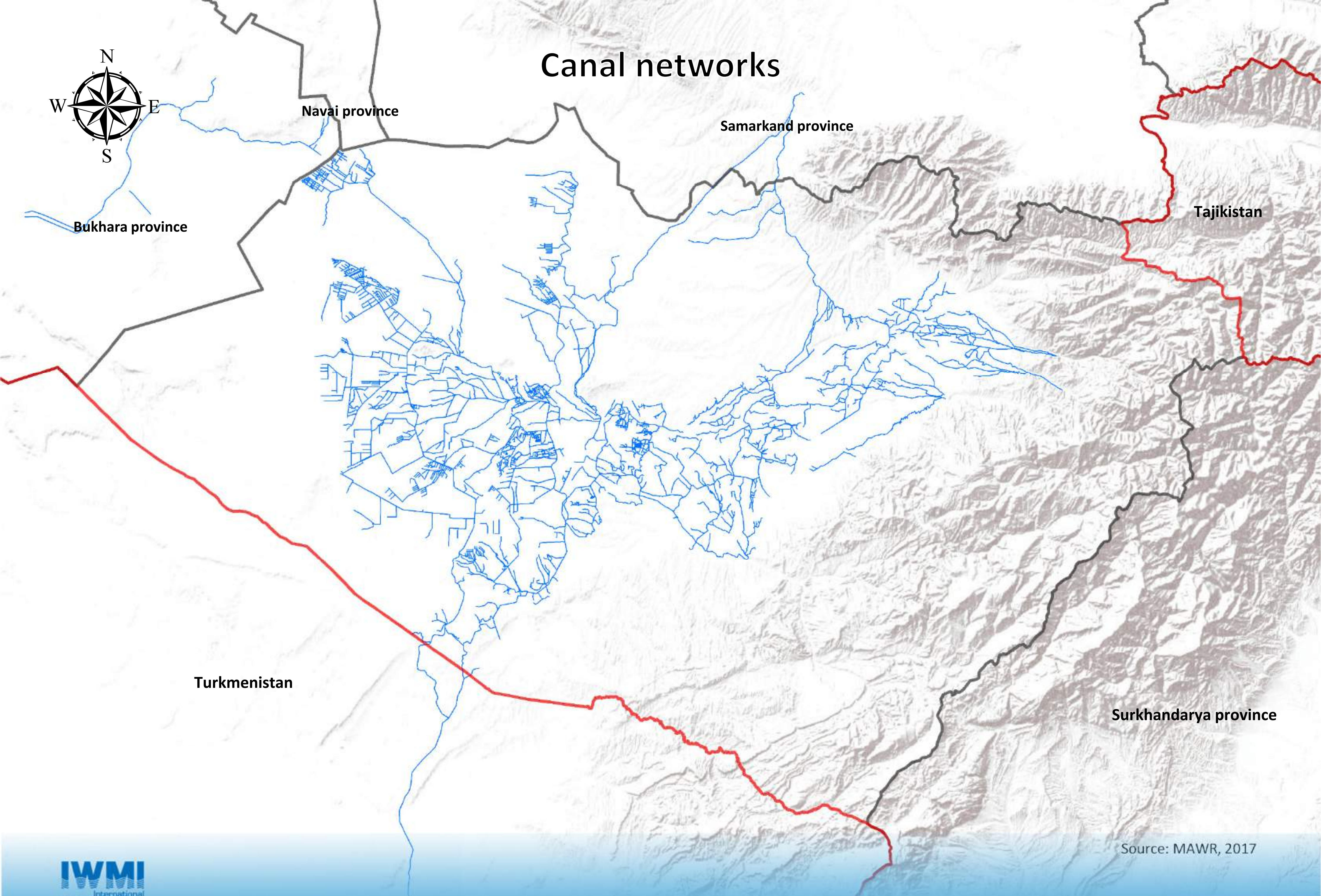


River networks

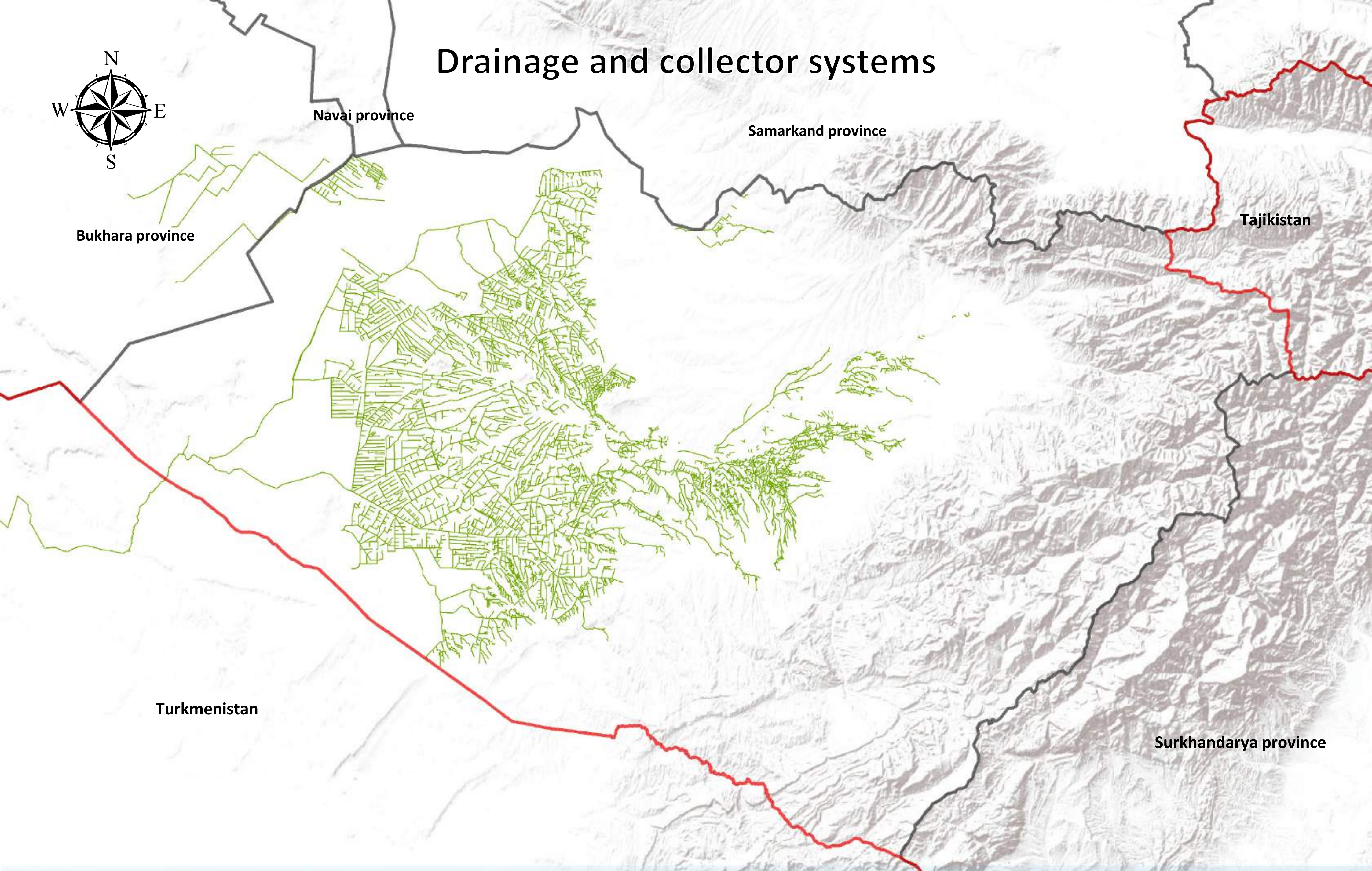


Source: MAWR, 2017

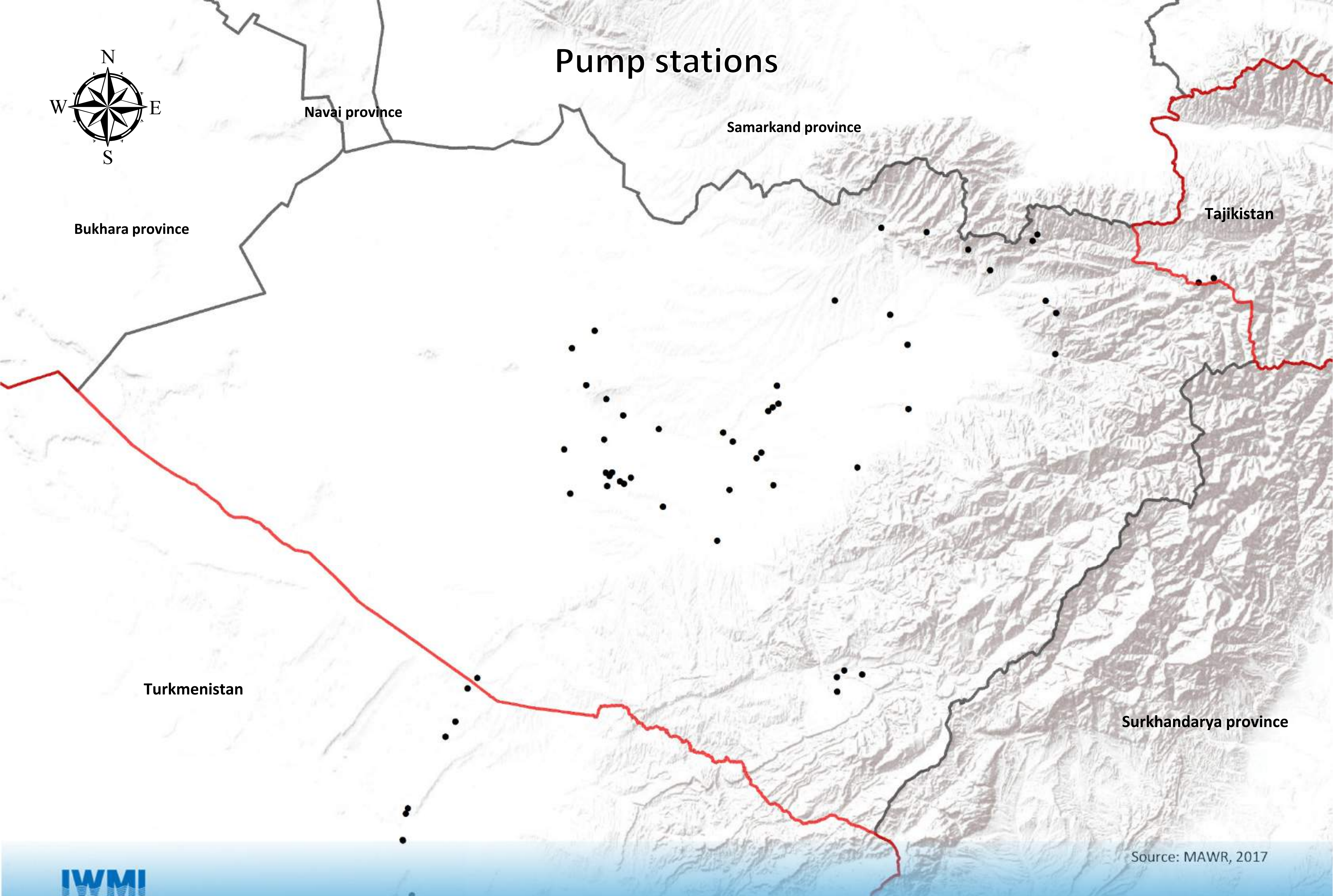
Canal networks



Drainage and collector systems

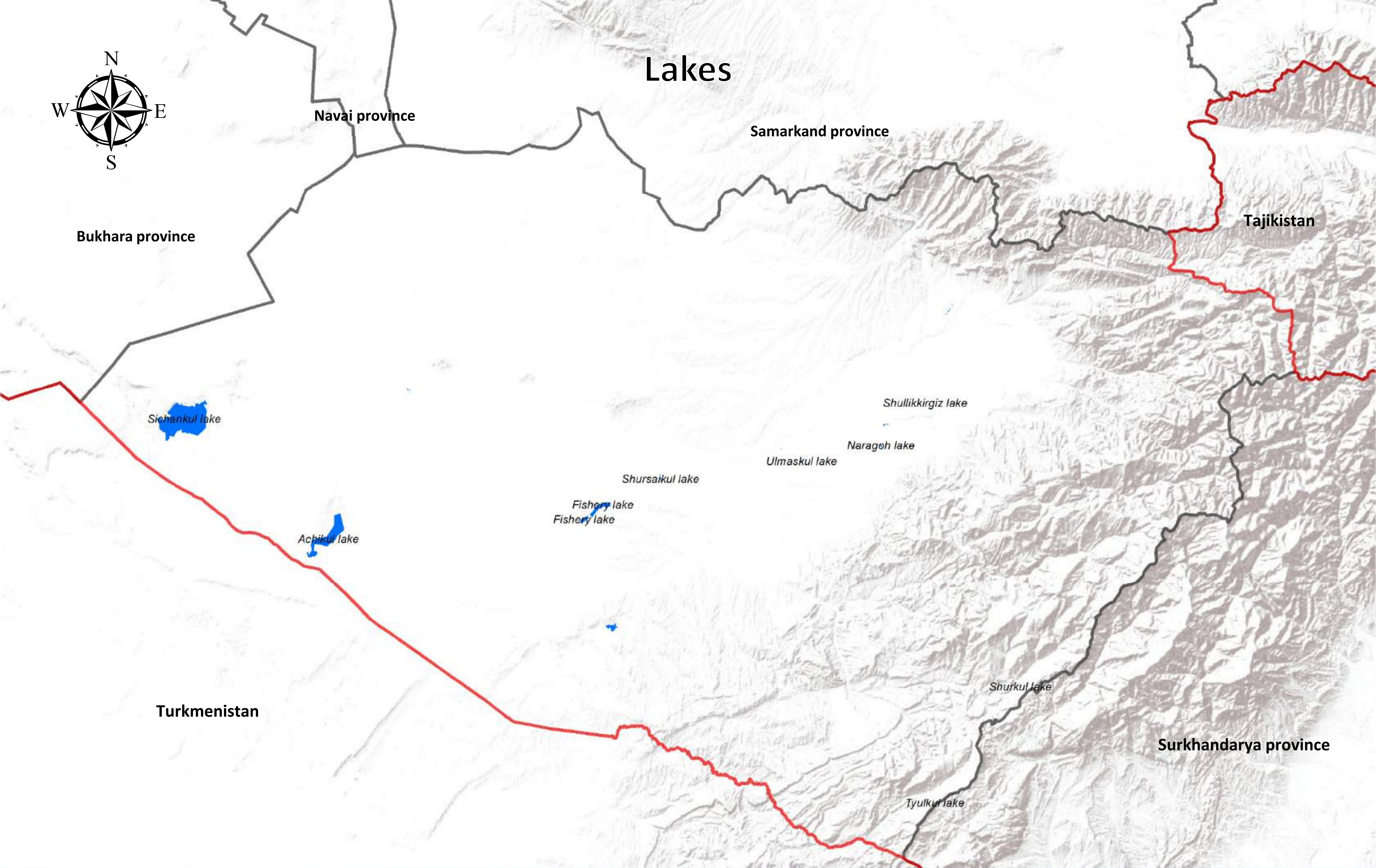


Pump stations



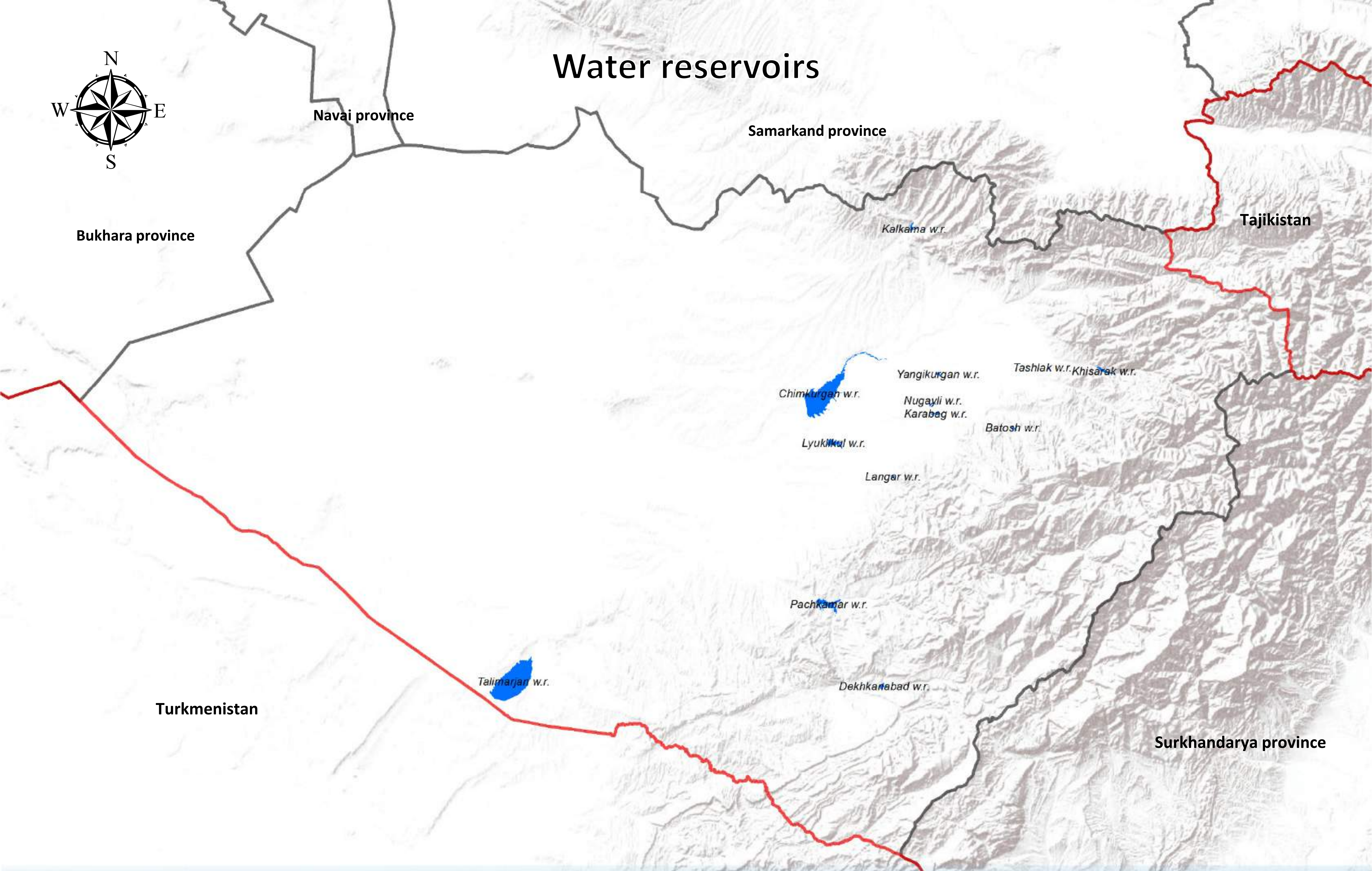
Source: MAWR, 2017

Lakes

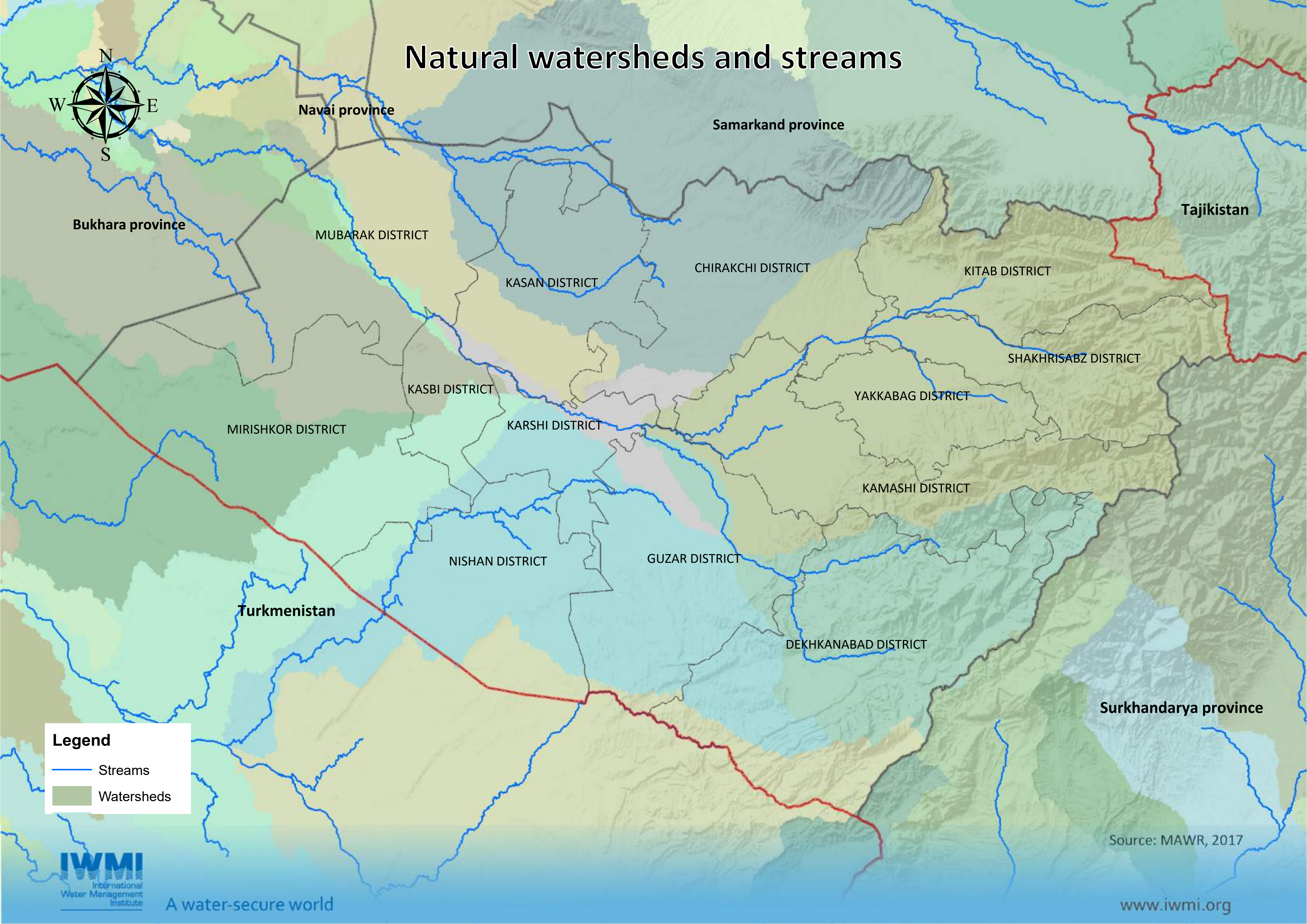


Source: MAWR, 2017

Water reservoirs



Source: MAWR, 2017



Natural watersheds and streams
N
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Navai province
Samarkand province
Bukhara province
Tajikistan
MUBARAK DISTRICT
KASAN DISTRICT
CHIRAKCHI DISTRICT
KITAB DISTRICT
SHAKHRISABZ DISTRICT
YAKKABAG DISTRICT
KASBI DISTRICT
KARSHI DISTRICT
MIRISHKOR DISTRICT
KAMASHI DISTRICT
NISHAN DISTRICT
GUZAR DISTRICT
Turkmenistan
DEKHKANABAD DISTRICT
Surkhandarya province
Legend
Streams
Watersheds
Source: MAWR, 2017
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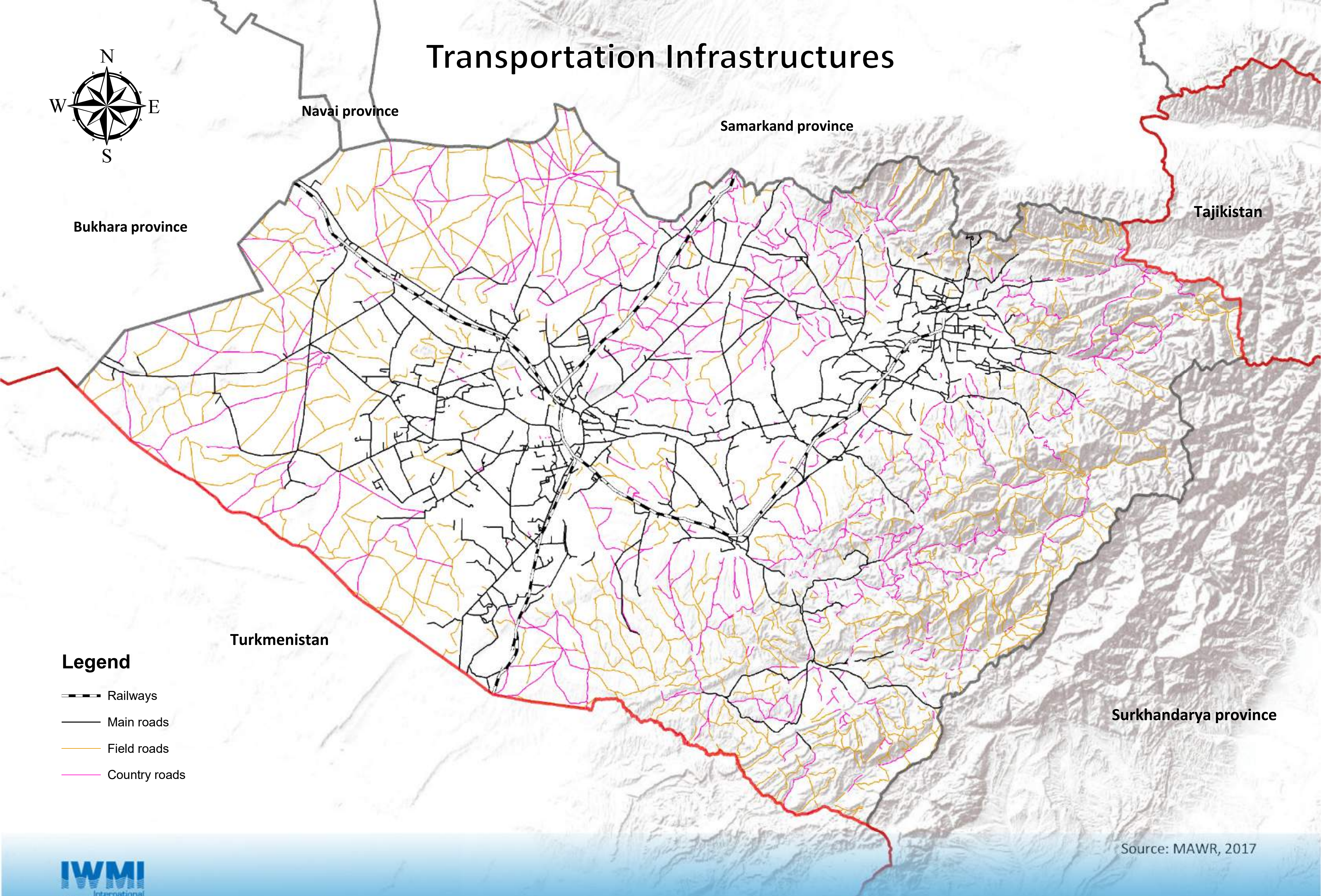
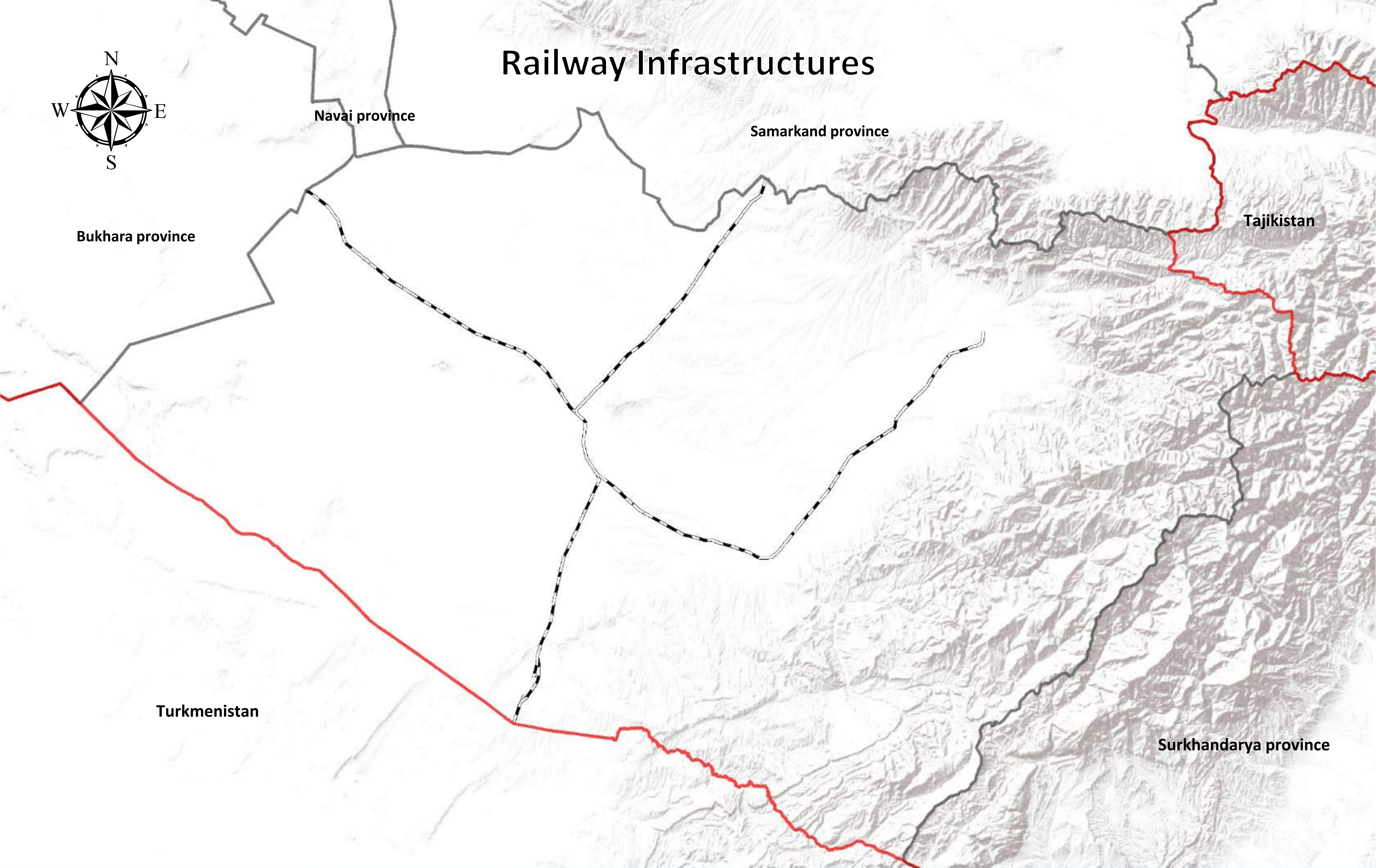
Transportation Infrastructures



Railway Infrastructures

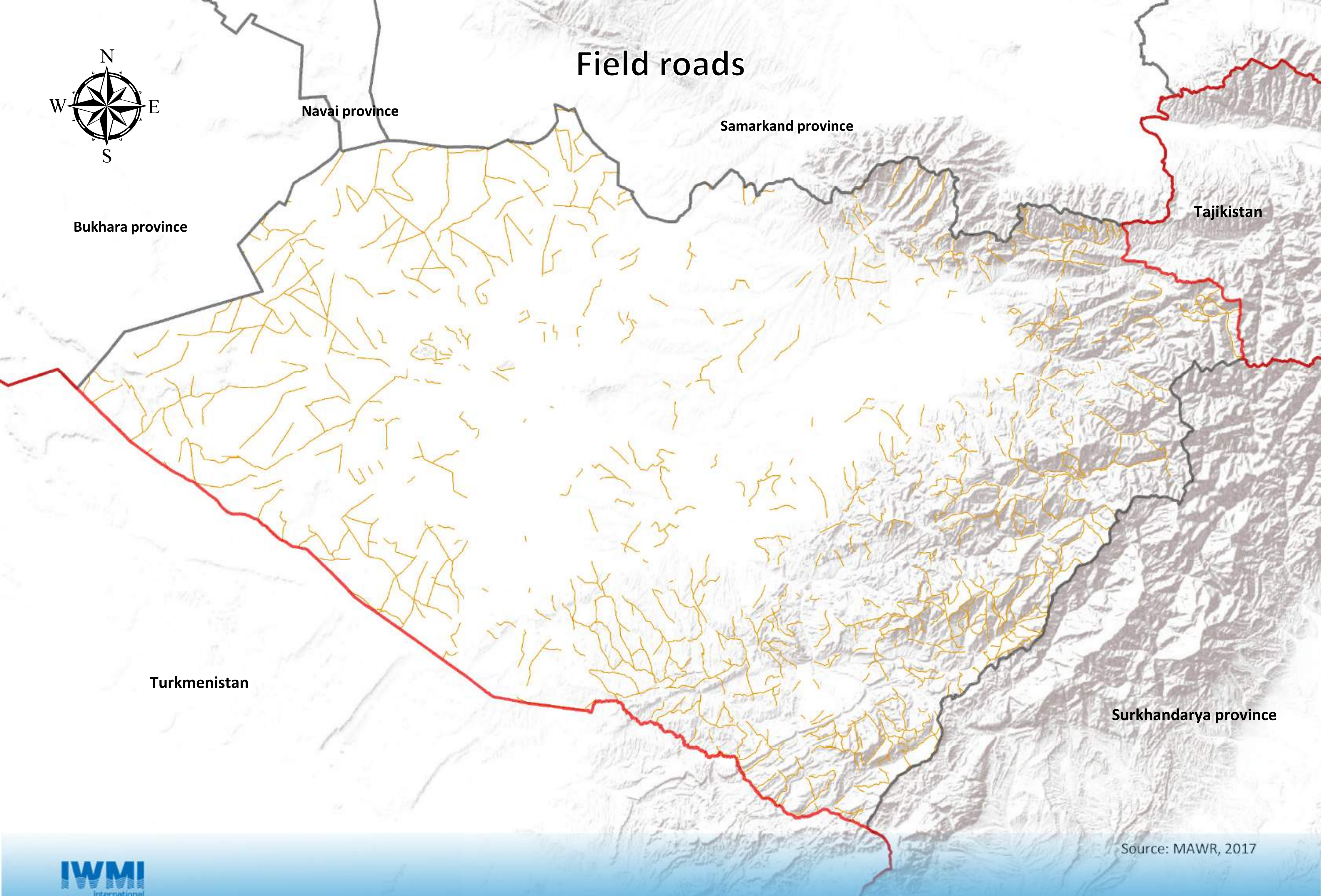


Source: MAWR, 2017

Main roads

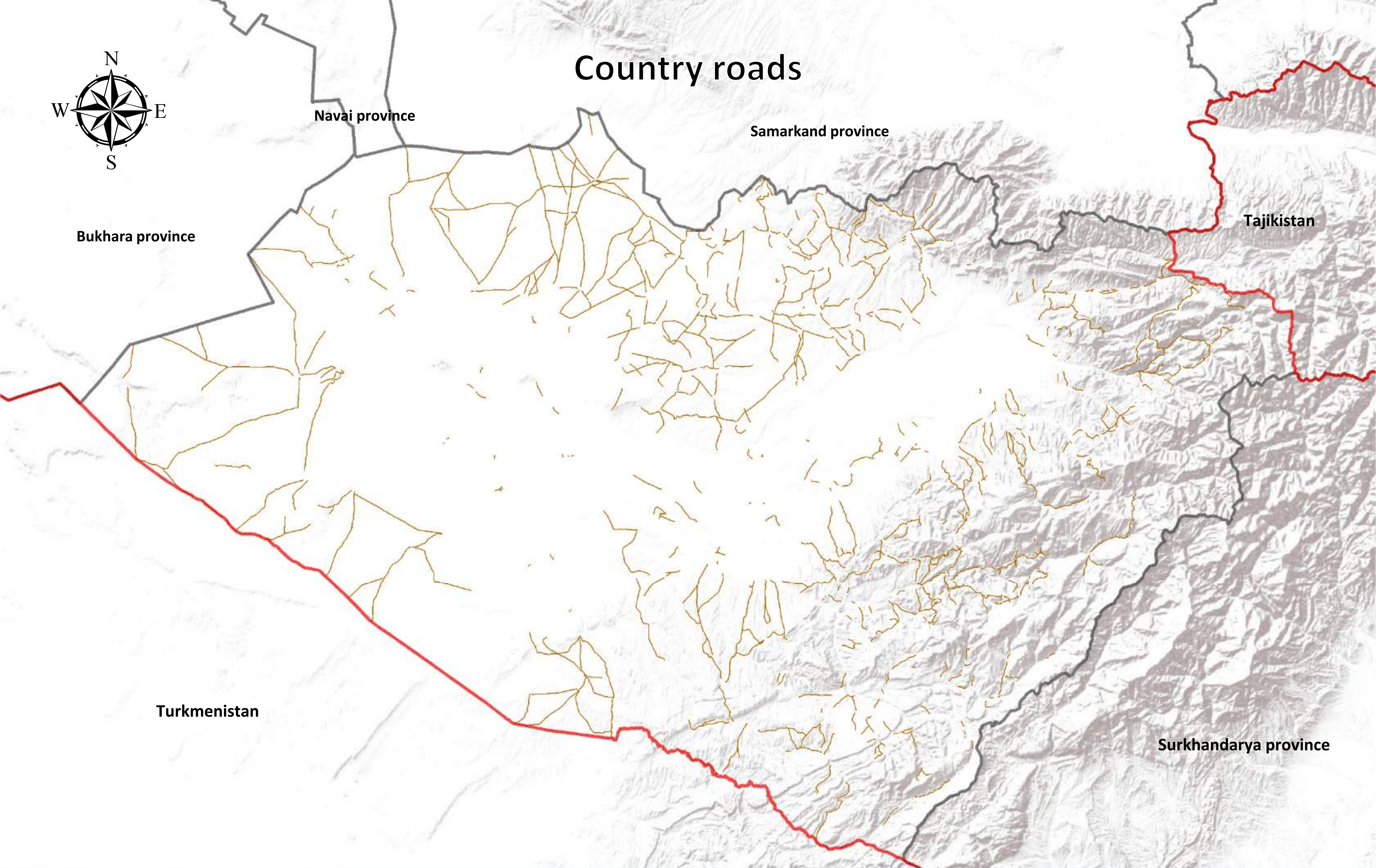
Source: MAWR, 2017

Field roads

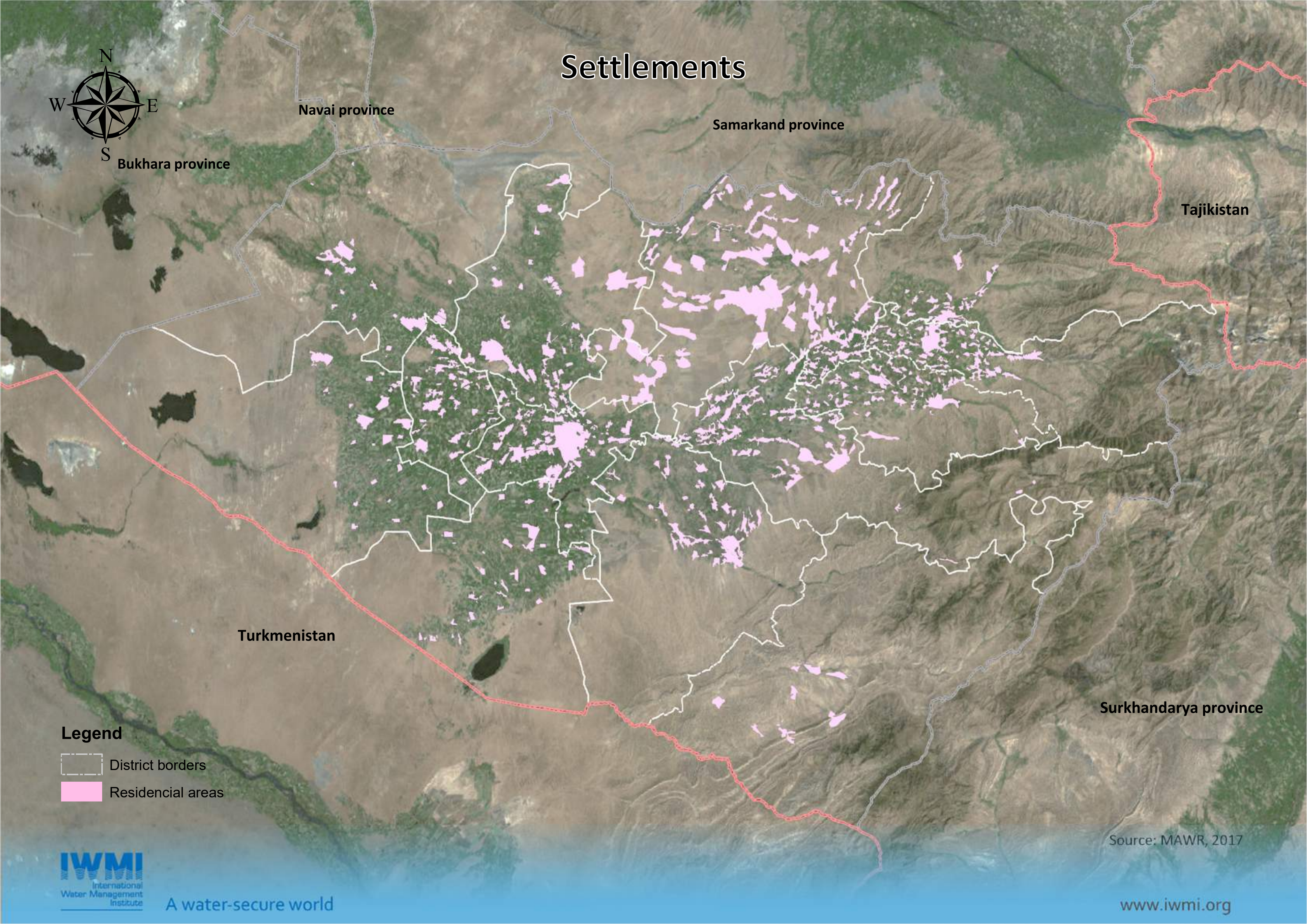


Source: MAWR, 2017

Country roads



Source: MAWR, 2017


Settlements
N
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Navai province
Samarkand province
Bukhara province
Tajikistan
Turkmenistan
Surkhandarya province
Legend
District borders
Residencial areas
Source: MAWR, 2017
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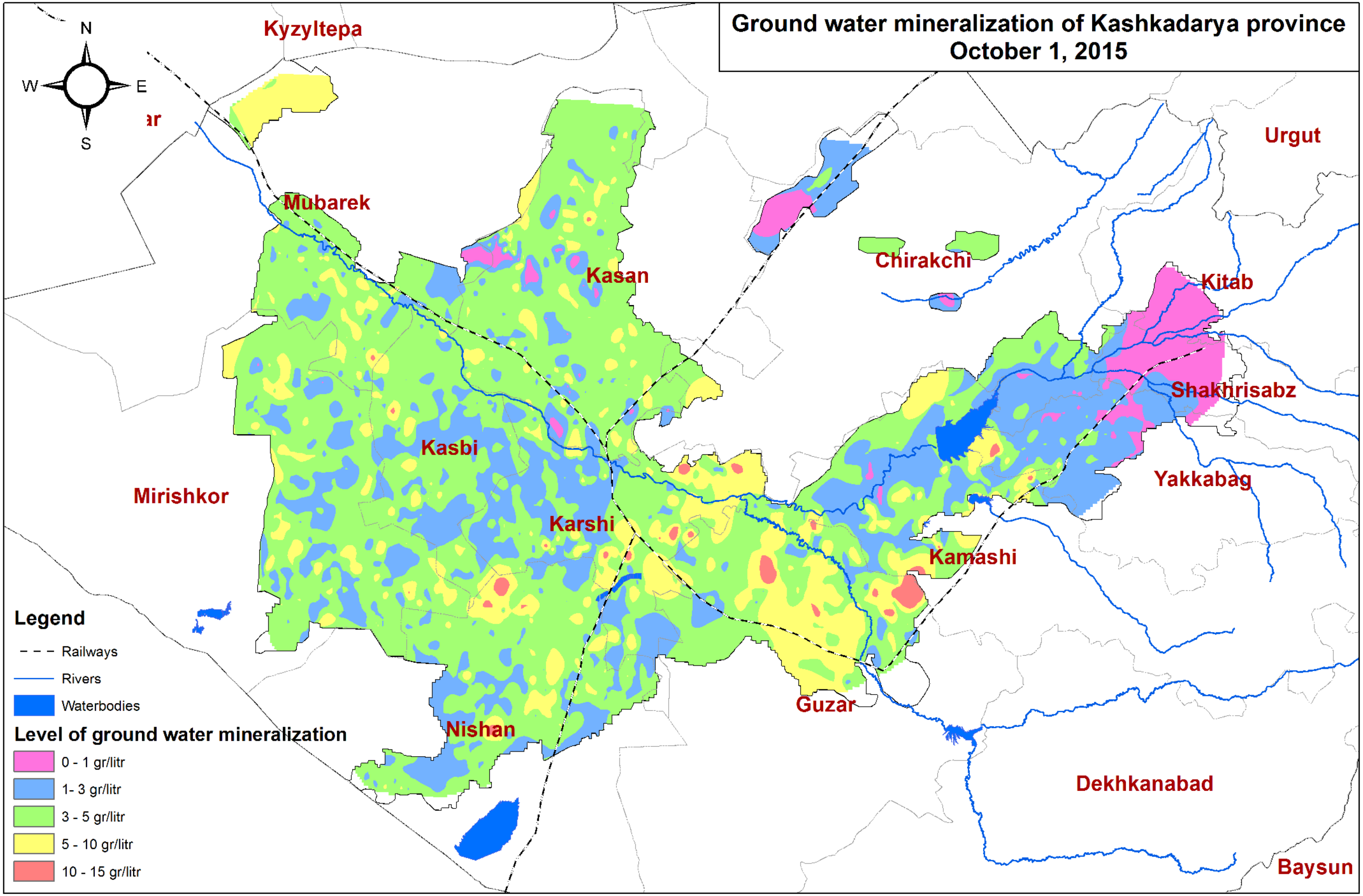
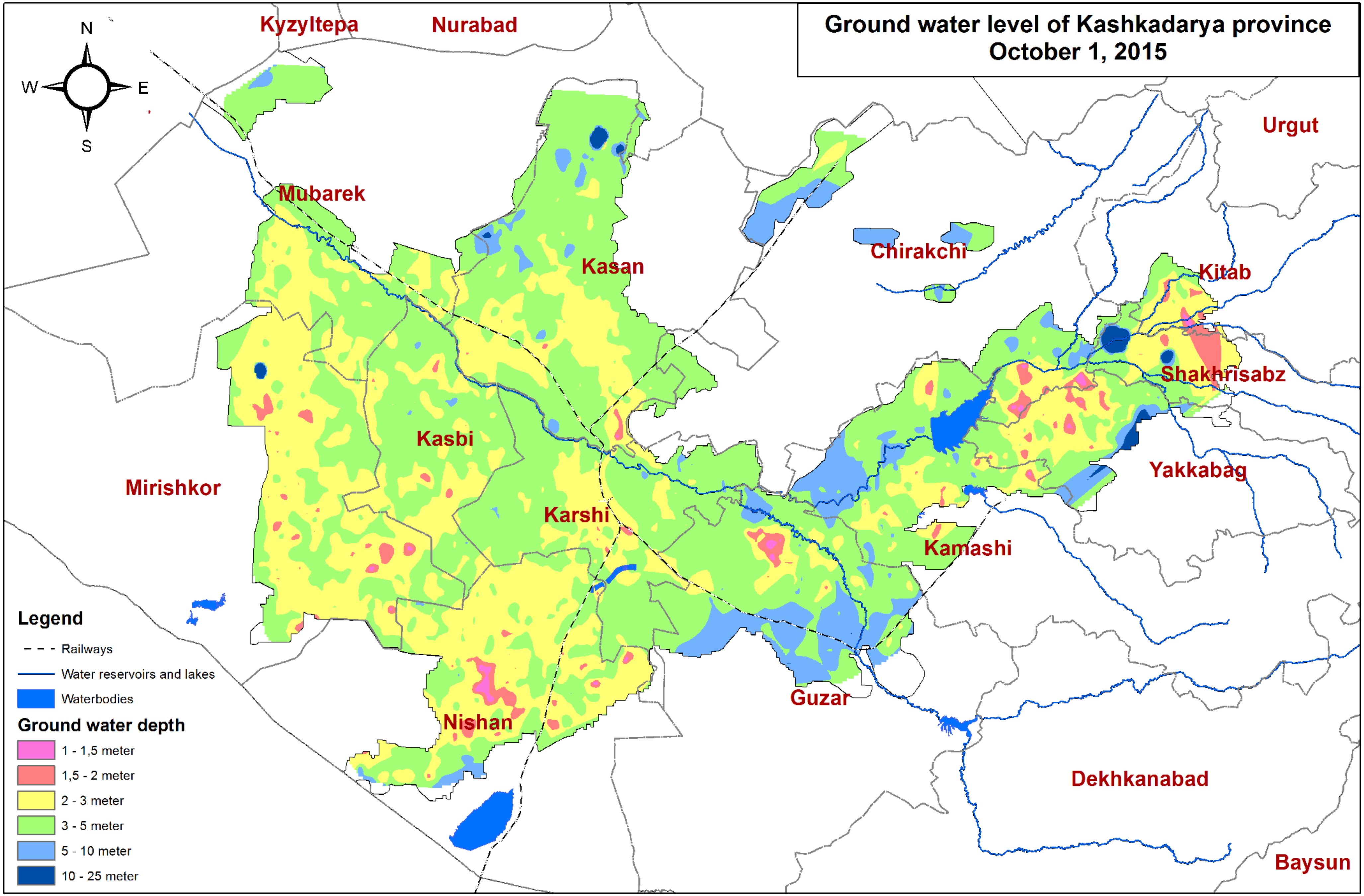
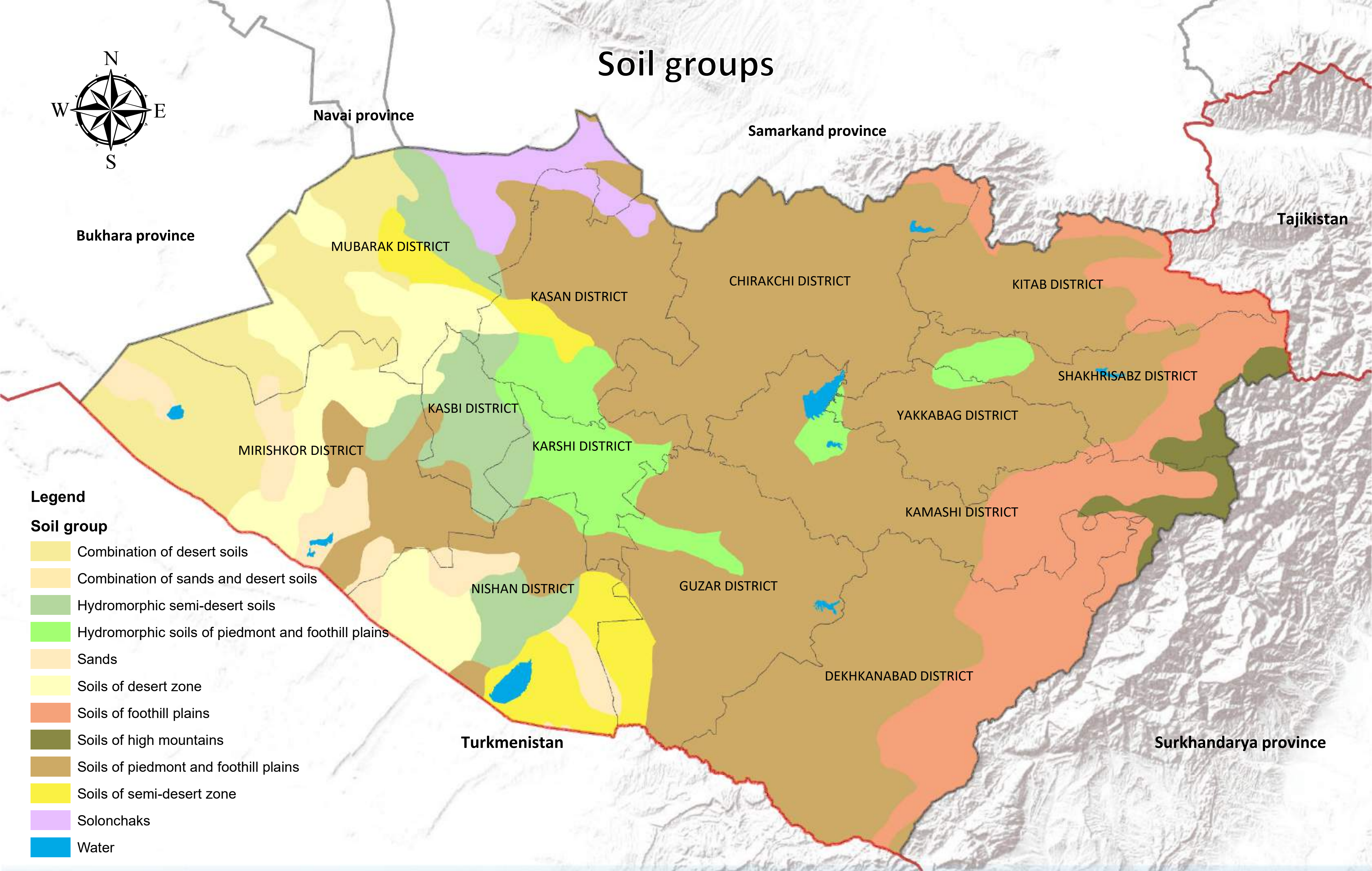


Source: UZGIP, 2015



Source: UZGIP, 2015



Soil groups
N
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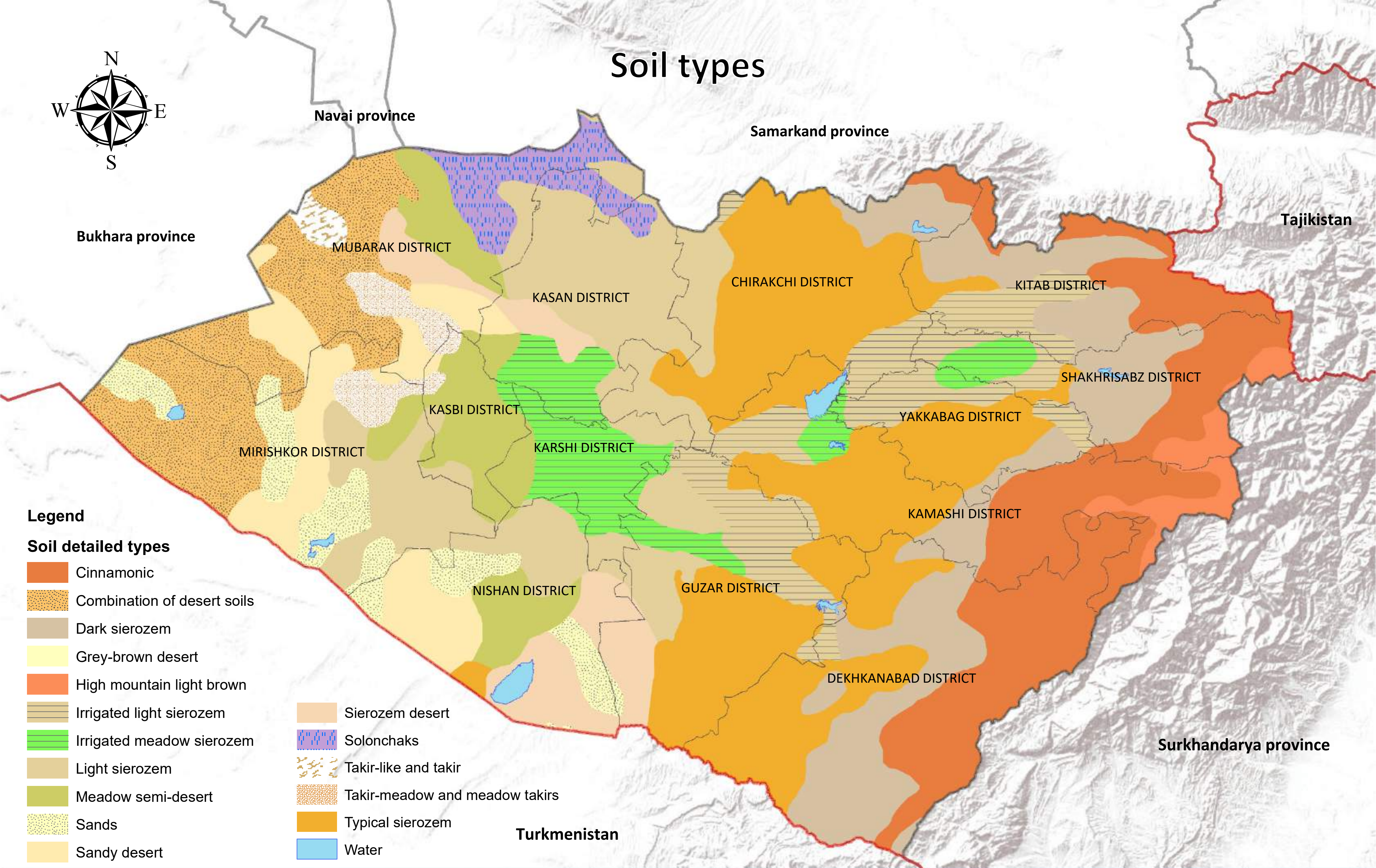
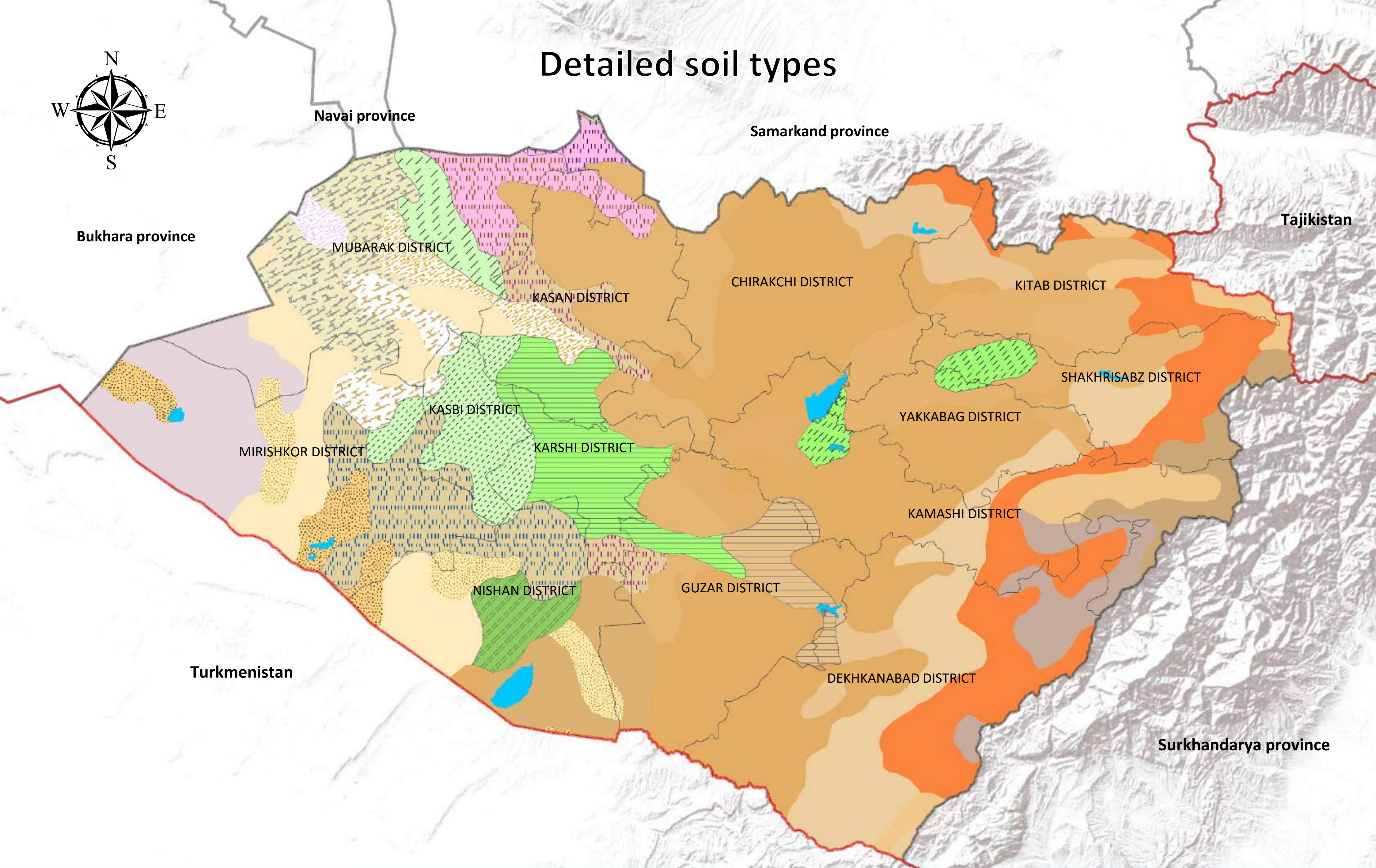
Navai province
Samarkand province
Tajikistan
Bukhara province
MUBARAK DISTRICT
KASAN DISTRICT
CHIRAKCHI DISTRICT
KITAB DISTRICT
SHAKHRISABZ DISTRICT
YAKKABAG DISTRICT
KASBI DISTRICT
KARSHI DISTRICT
MIRISHKOR DISTRICT
KAMASHI DISTRICT
NISHAN DISTRICT
GUZAR DISTRICT
DEKHKANABAD DISTRICT
Turkmenistan
Surkhandarya province
Legend
Soil group
Combination of desert soils
Combination of sands and desert soils
Hydromorphic semi-desert soils
Hydromorphic soils of piedmont and foothill plains
Sands
Soils of desert zone
Soils of foothill plains
Soils of high mountains
Soils of piedmont and foothill plains
Soils of semi-desert zone
Solonchaks
Water
Source: ICARDA, 2012

Soil types



Source: ICARDA, 2012

Detailed soil types

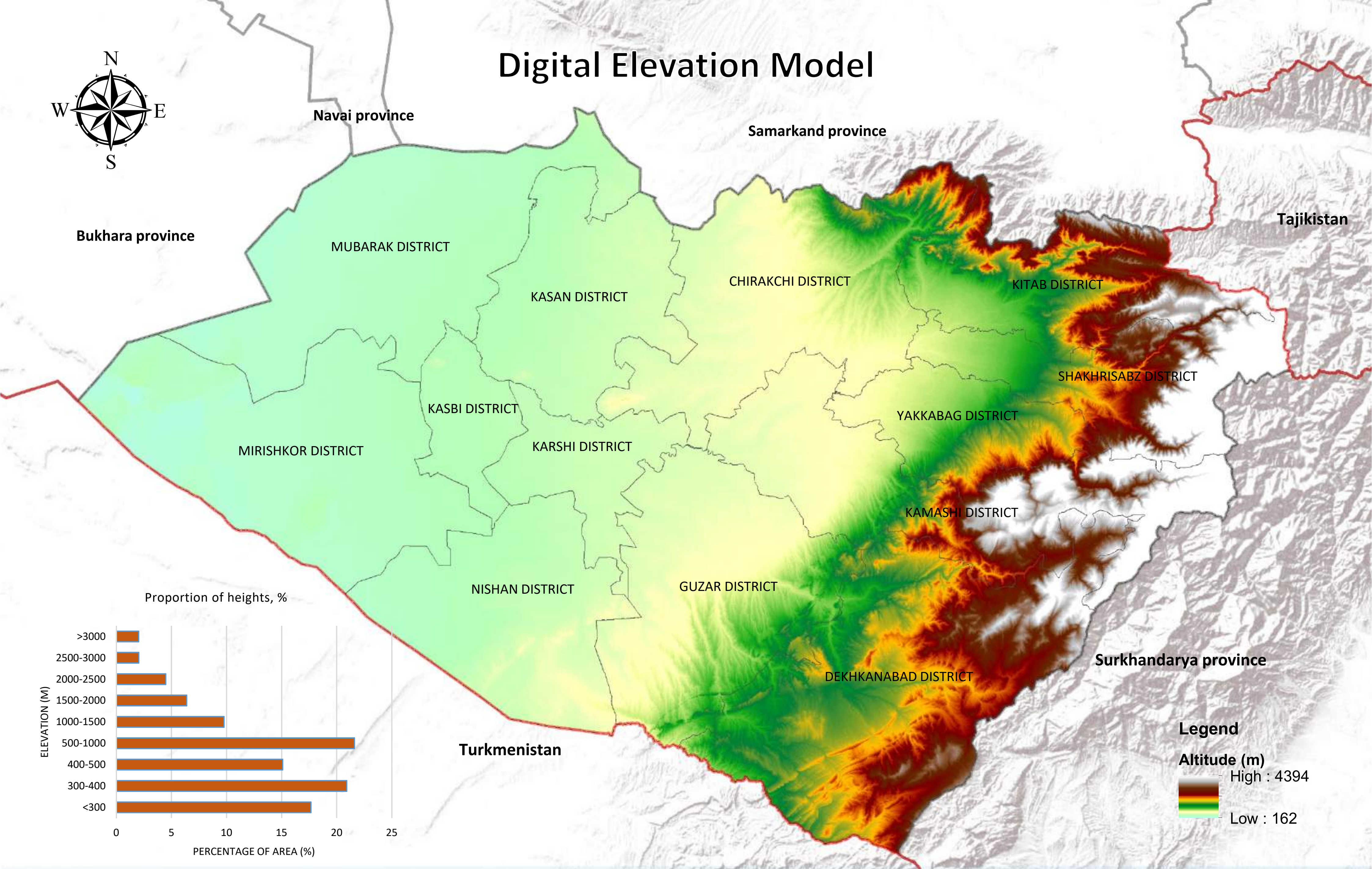


Source: ICARDA, 2012

Legend

Soil types

- "Shor" and other solonchaks on elluvium of parent rocks
- Blown and poor fixed sands
- Cinnamonic slightly leached clayey and loamy on deluvium
- Cinnamonic slightly leached coarse-skeletal on eluvium and deluvium
- Cinnamonic typical clayey and loamy on eluvium and deluvium
- Dark sierozems coarse-skeletal on eluvium and proluvium
- Dark sierozems eroded skeletal-loamy on eluvium and proluvium
- Dark sierozems loamy and clayey on loesses
- Desert -sierozem meadow
- Desert sandy solonchak-like on wind deposits, proluvium and aluvium
- Grey-brown eroded skeletal on skeleton eluvium
- Grey-brown sierozem meadow
- Grey-brown solonchak-like loamy-sandy on eluvium of sandstone in complex with sand ripples
- Irrigated meadow-sierozem and meadow-oasis saline and leached on aluvium and proluvium
- Light brown high-mountaineous skeletal-loamy and coarse-skeletal on eluvium and deluvium
- Light irrigated sierozem and sierozem-oasis loamy and loamy sandy on aluvium and proluvium
- Light sierozem subtropic hot unfreeze throuch
- Light sierozems
- Light sierozems here and there solonchak-like, skeletal-loamy on proluvium
- Light sierozems loamy on loess-like sediments
- Light sierozems solonchak-like on alluvial and proluvial loess-like deposits
- Light-brown desert subtropic unfreeze through
- Meadow and marsh solonchak and solonchak-like
- Meadow takirs and takirs
- Meadow-like grey brown-sierozem
- Meadow-oasis clay and loamy-sandy on aluvium and proluvium
- Sands
- Sierozem-grey-brown
- Sierozem-oasis loamy and loamy sandy on aluvium and proluvium
- Sierozem-oasis saline and typical irrigated soils
- Sierozem-takir
- Takir-like and takirs here and there in complex with sands
- Takir-like solonchak-like on aluvium and proluvium
- Typical sierozem subtropic hot unfreeze throuch
- Typical sierozems loamy on loesses
- Water



Source: IWMI, 2017

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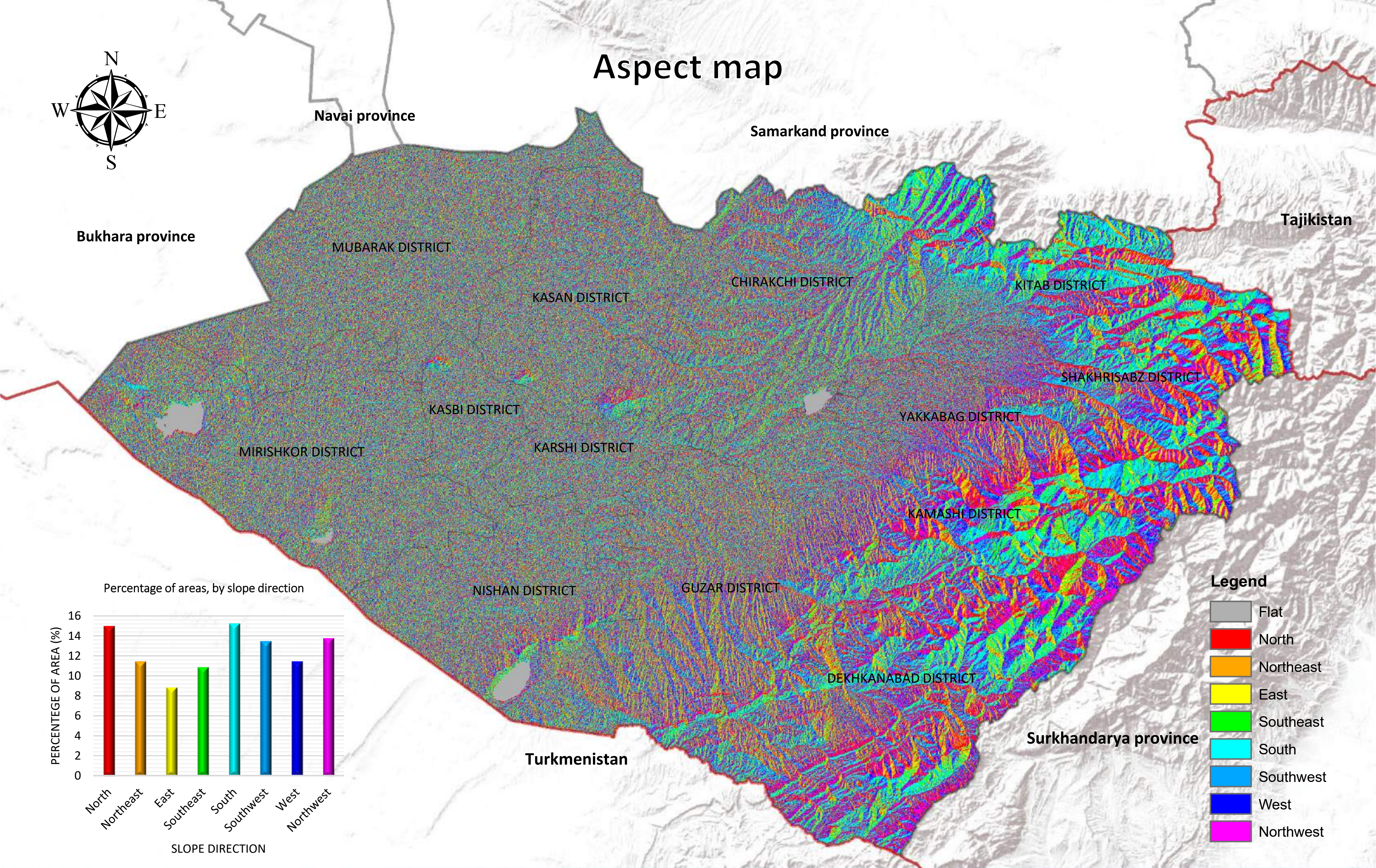
Aspect map



Source: IWMI, 2017

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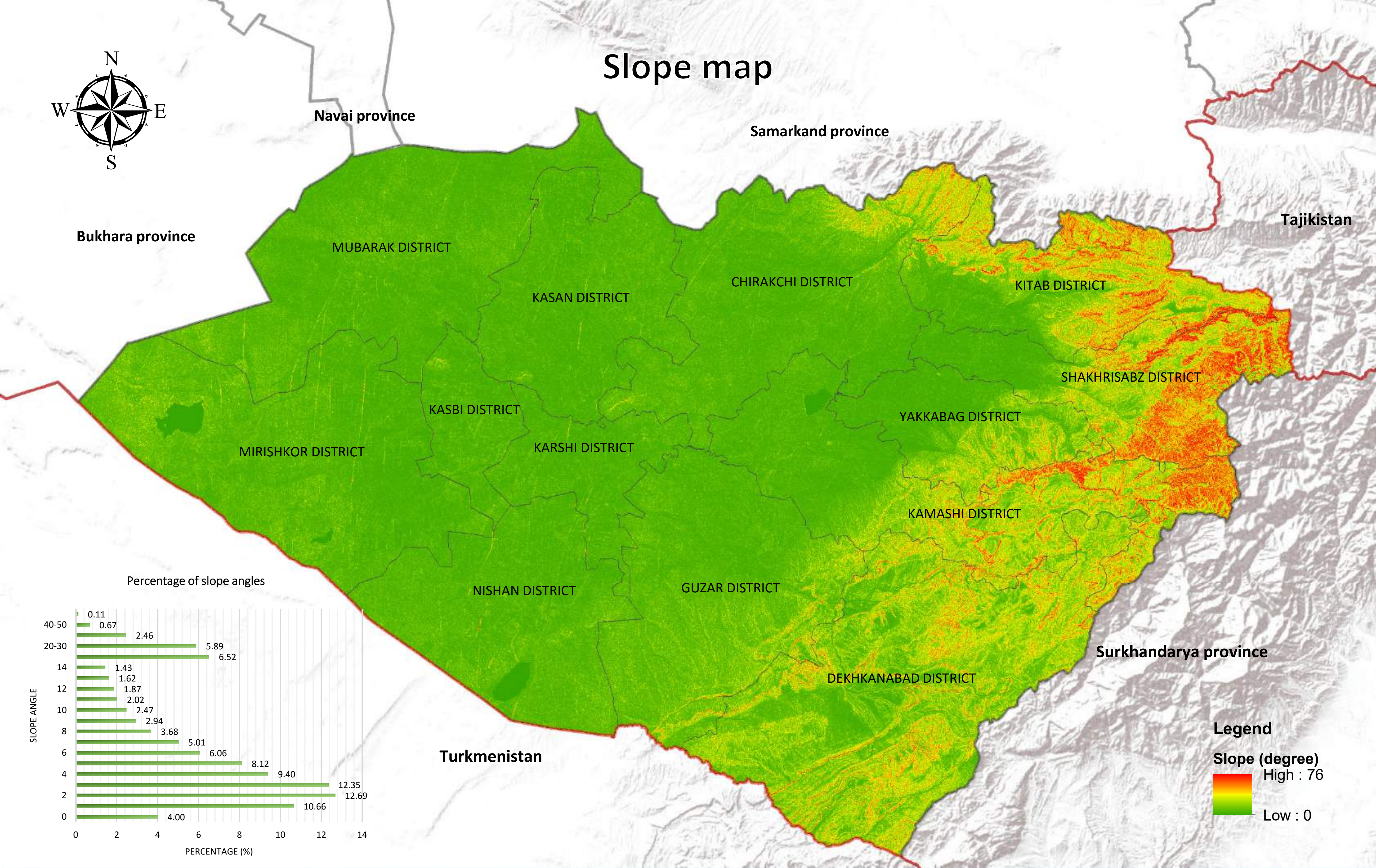
Slope map



Source: IWMI, 2017

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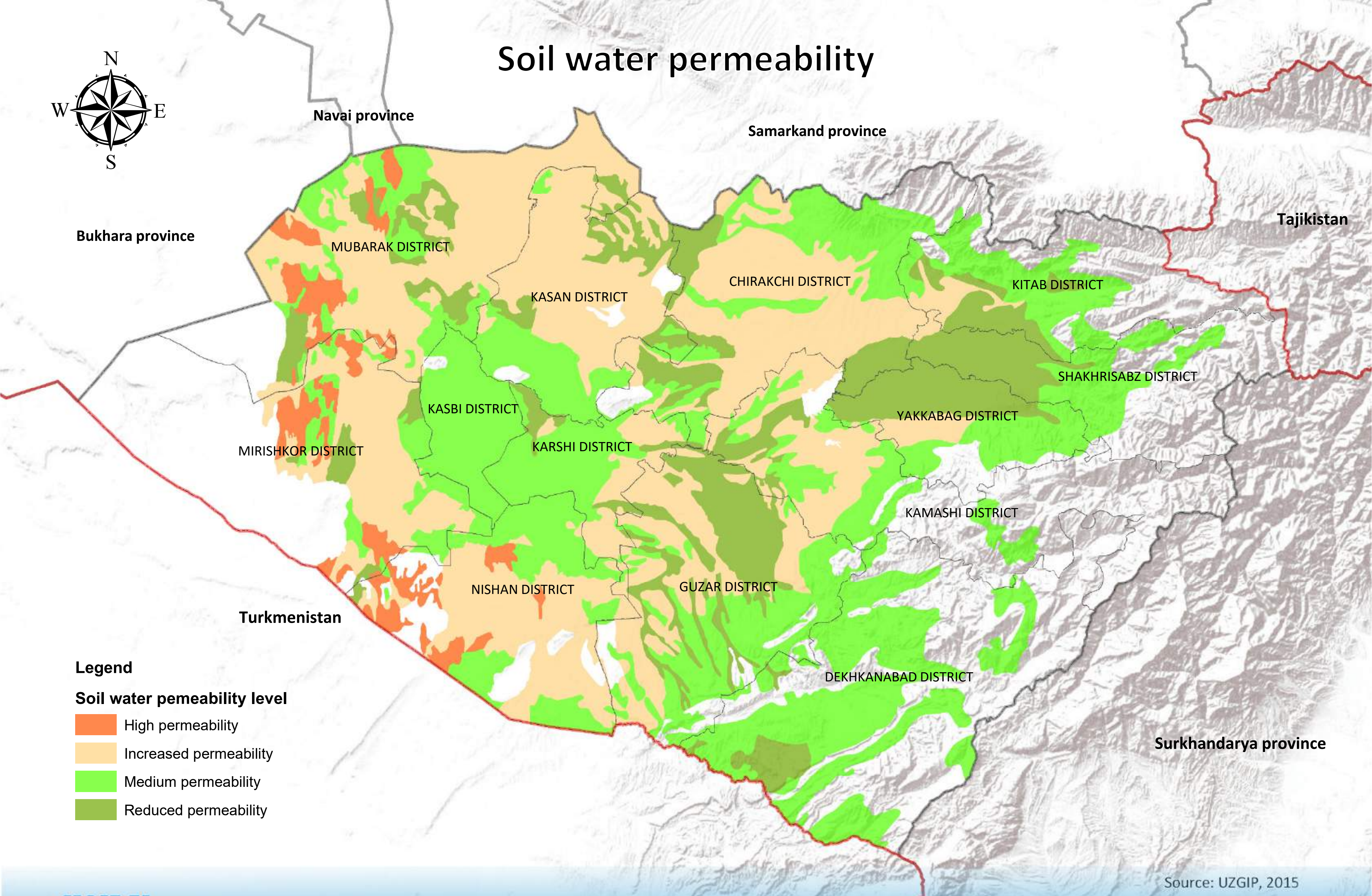
Soil water permeability



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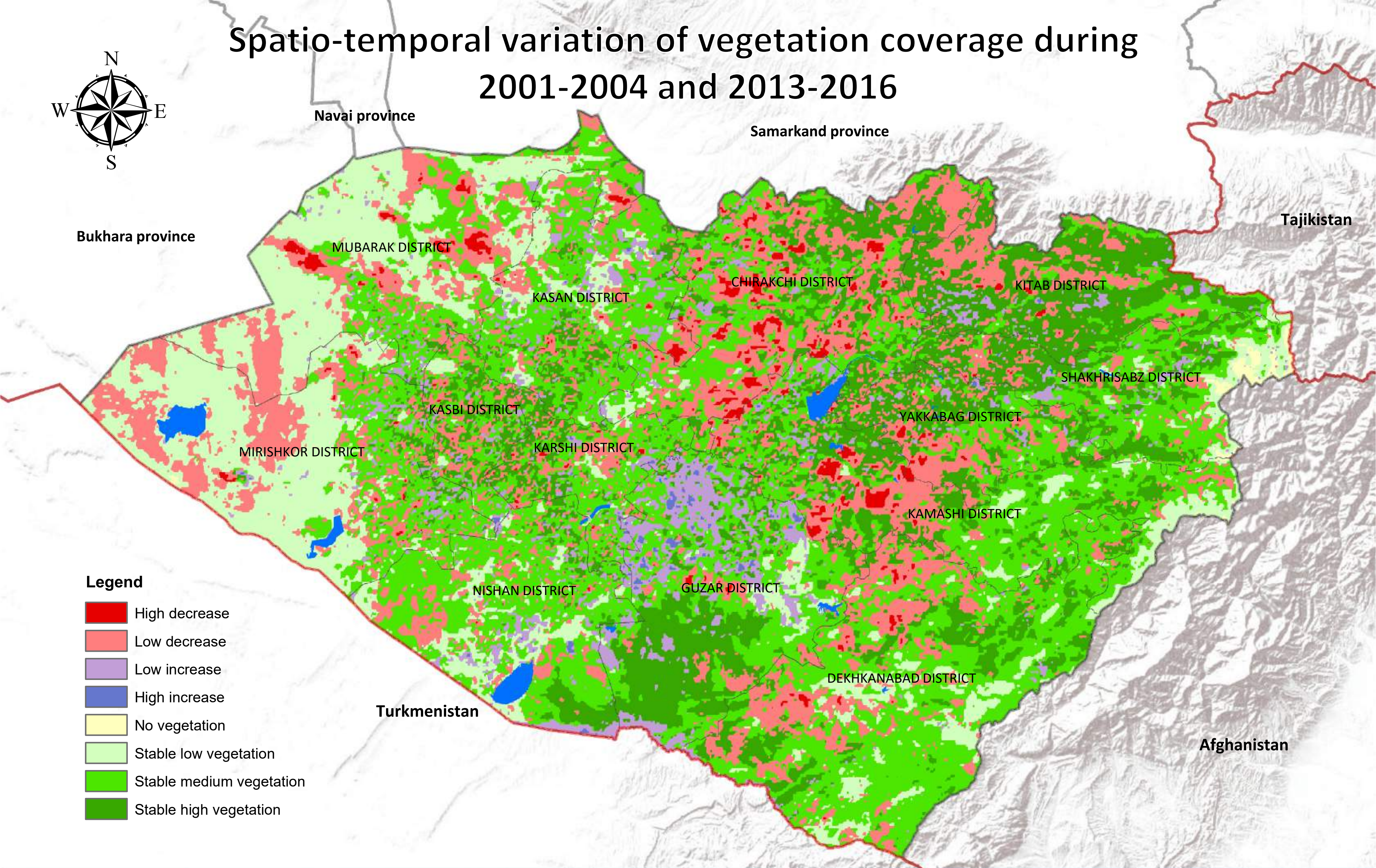
Spatio-temporal variation of vegetation coverage during 2001-2004 and 2013-2016



Source: ICARDA, 2012

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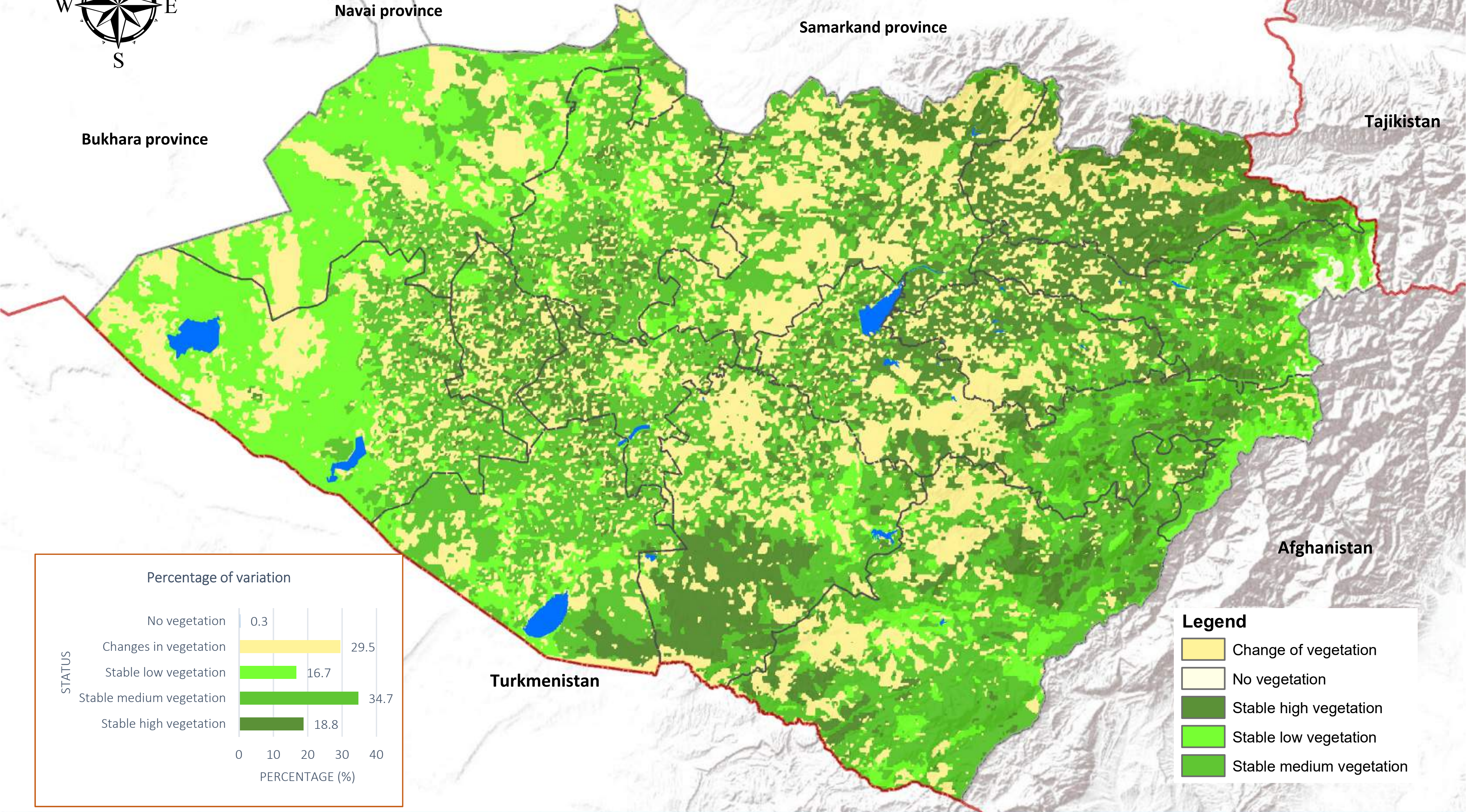
Spatio-temporal variation of vegetation coverage during 2001-2004 and 2013-2016



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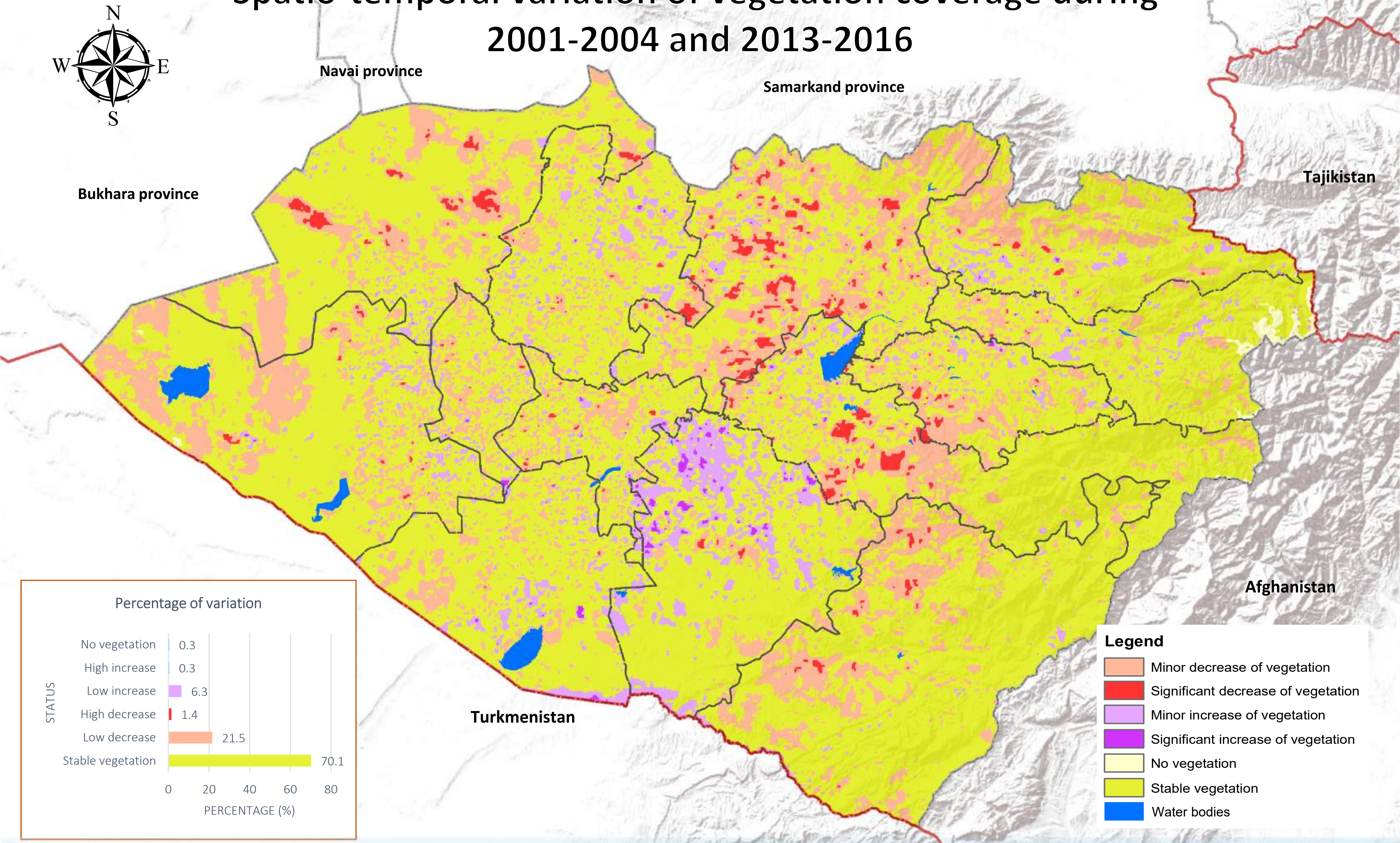
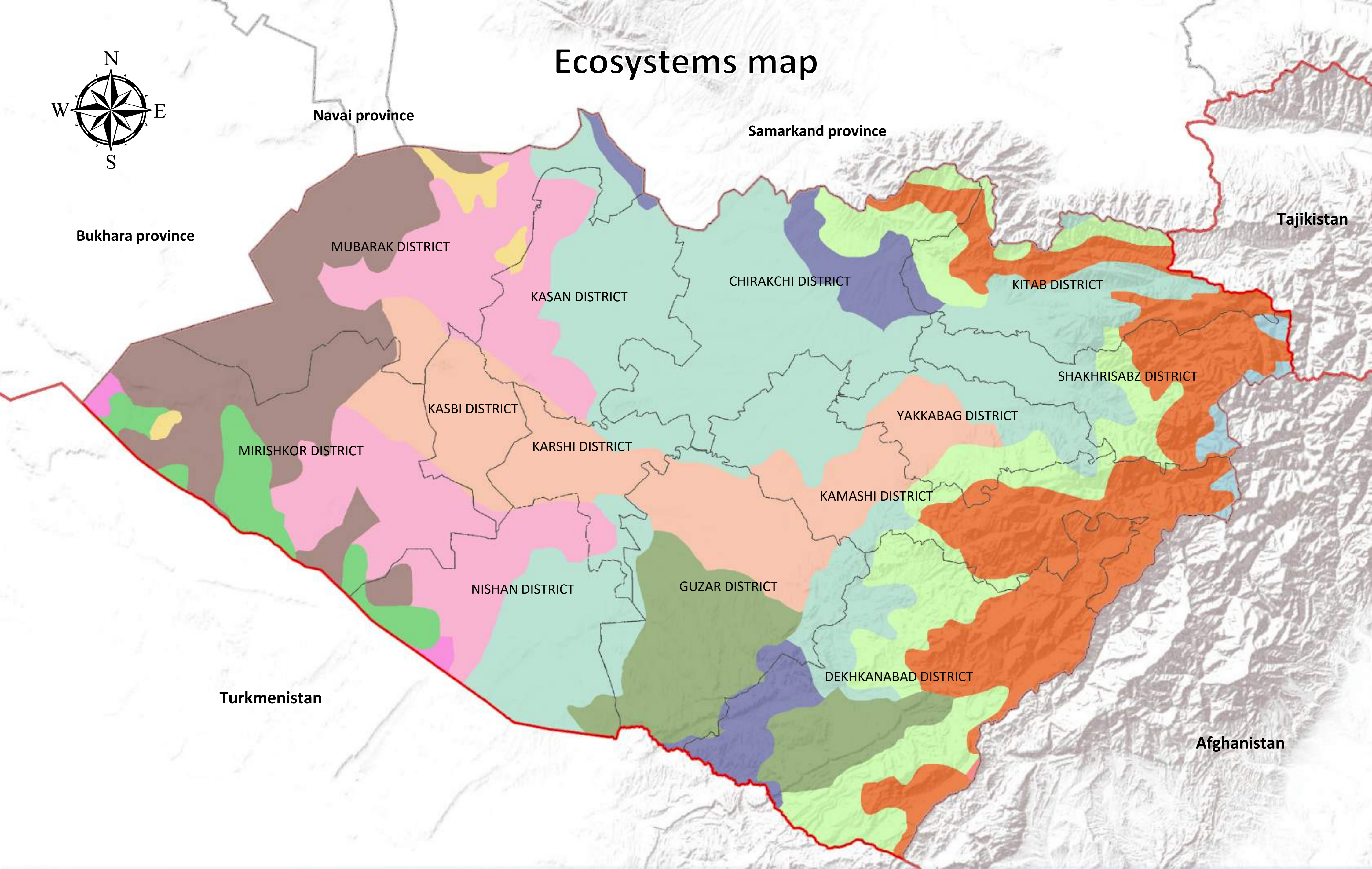
Spatio-temporal variation of vegetation coverage during 2001-2004 and 2013-2016



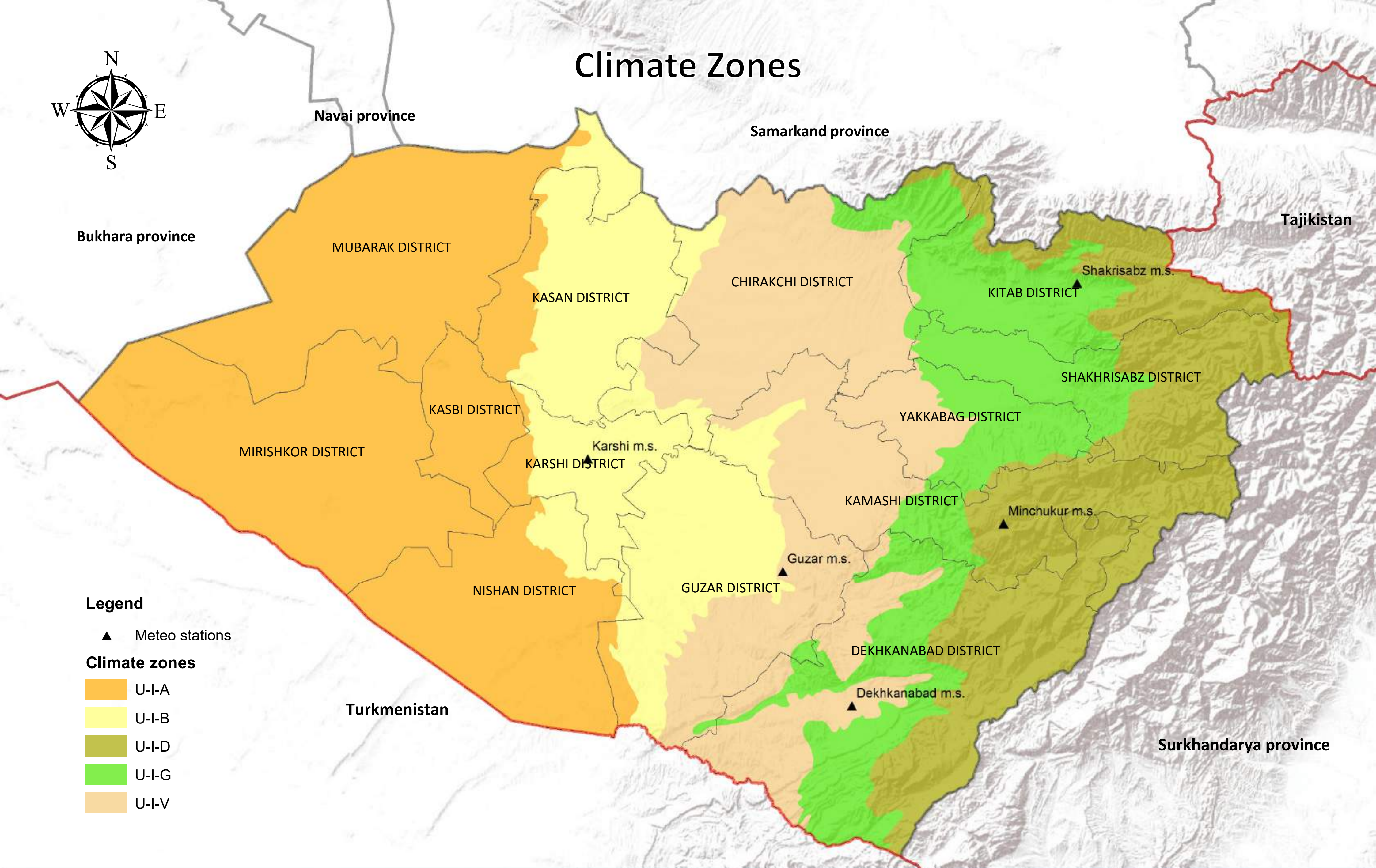
Source: IWMI, 2017

Ecosystems map

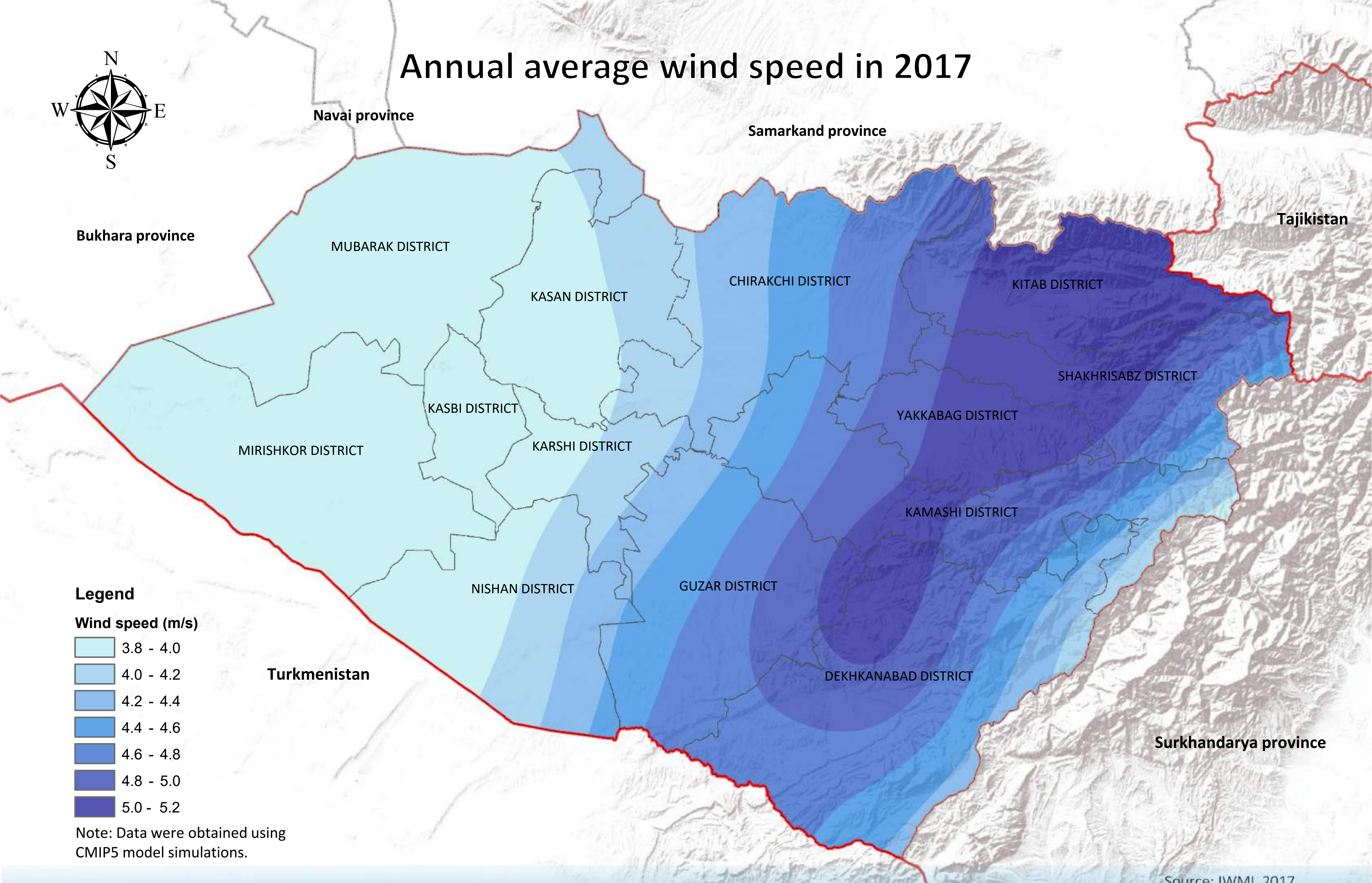


Source: ICARDA, 2012

Climate Zones

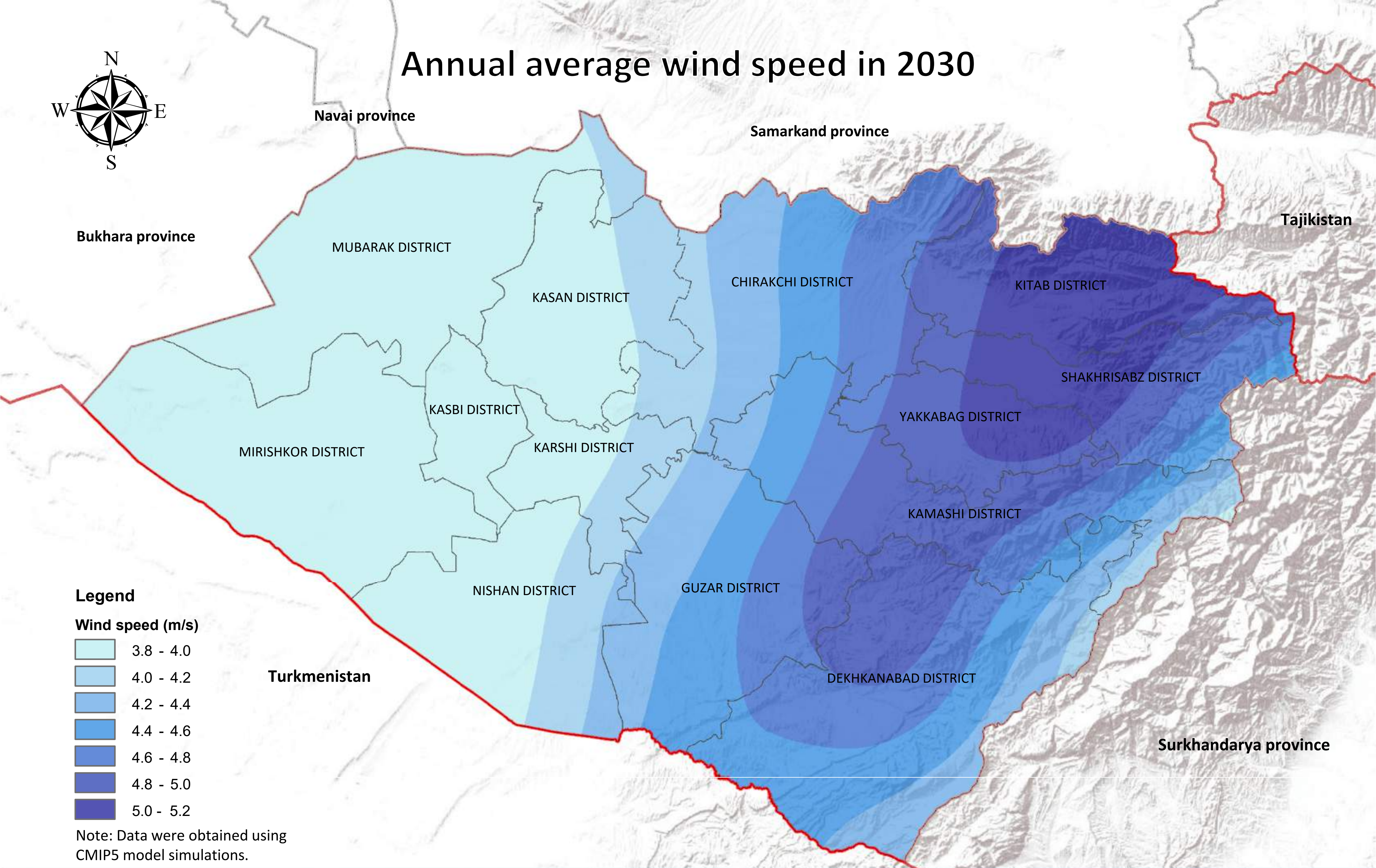


Annual average wind speed in 2017

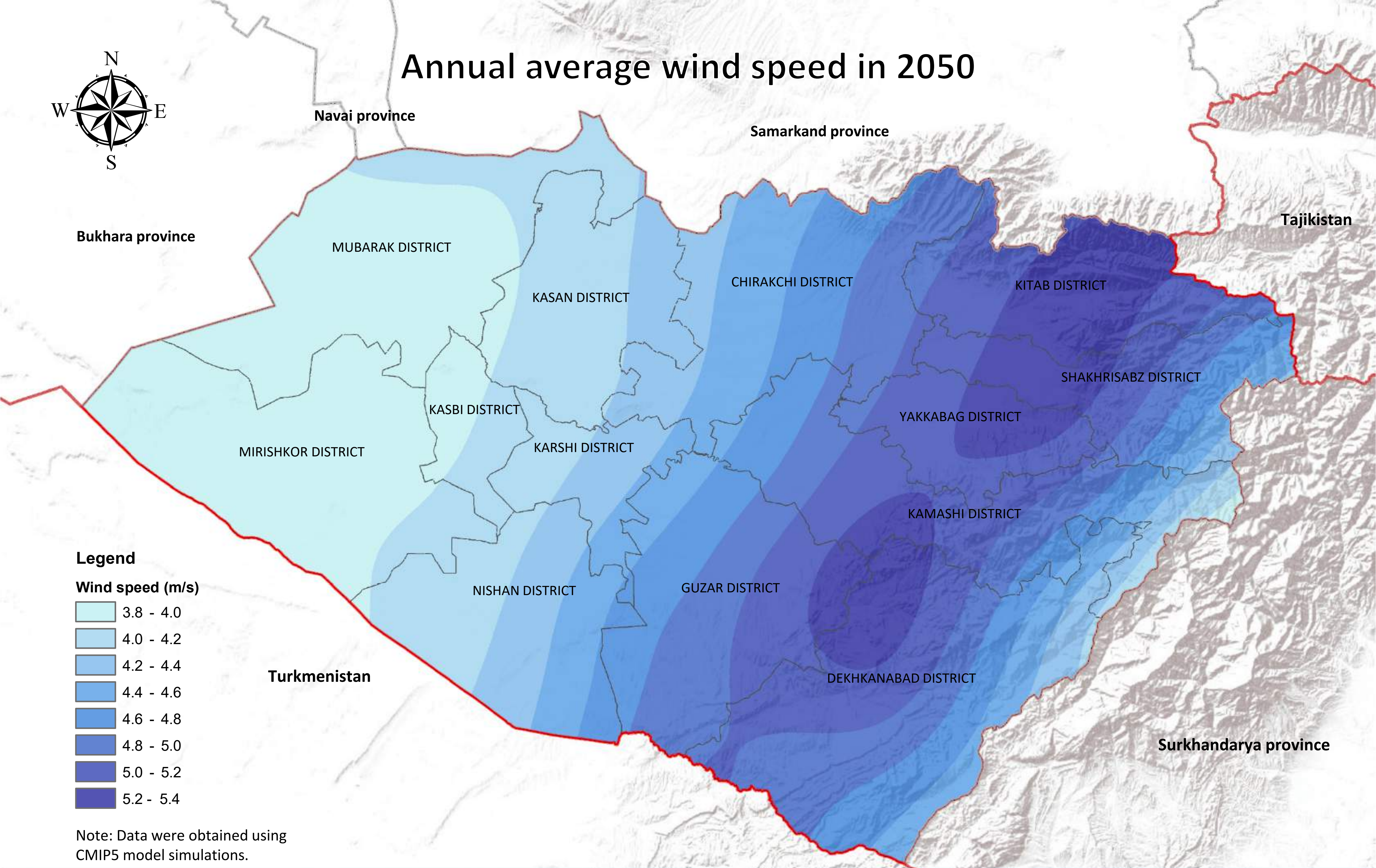


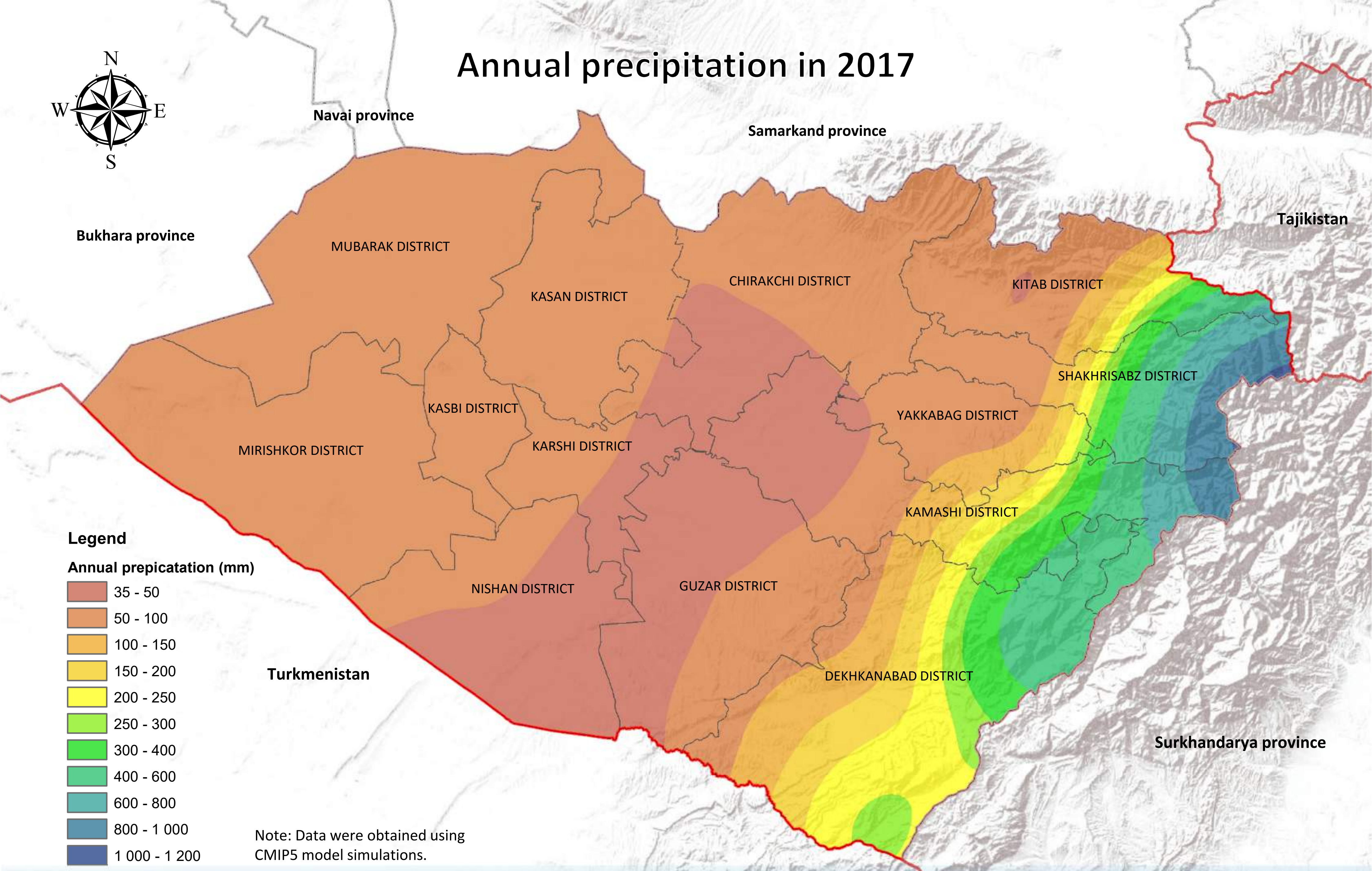
Note: Data were obtained using CMIP5 model simulations.

Annual average wind speed in 2030



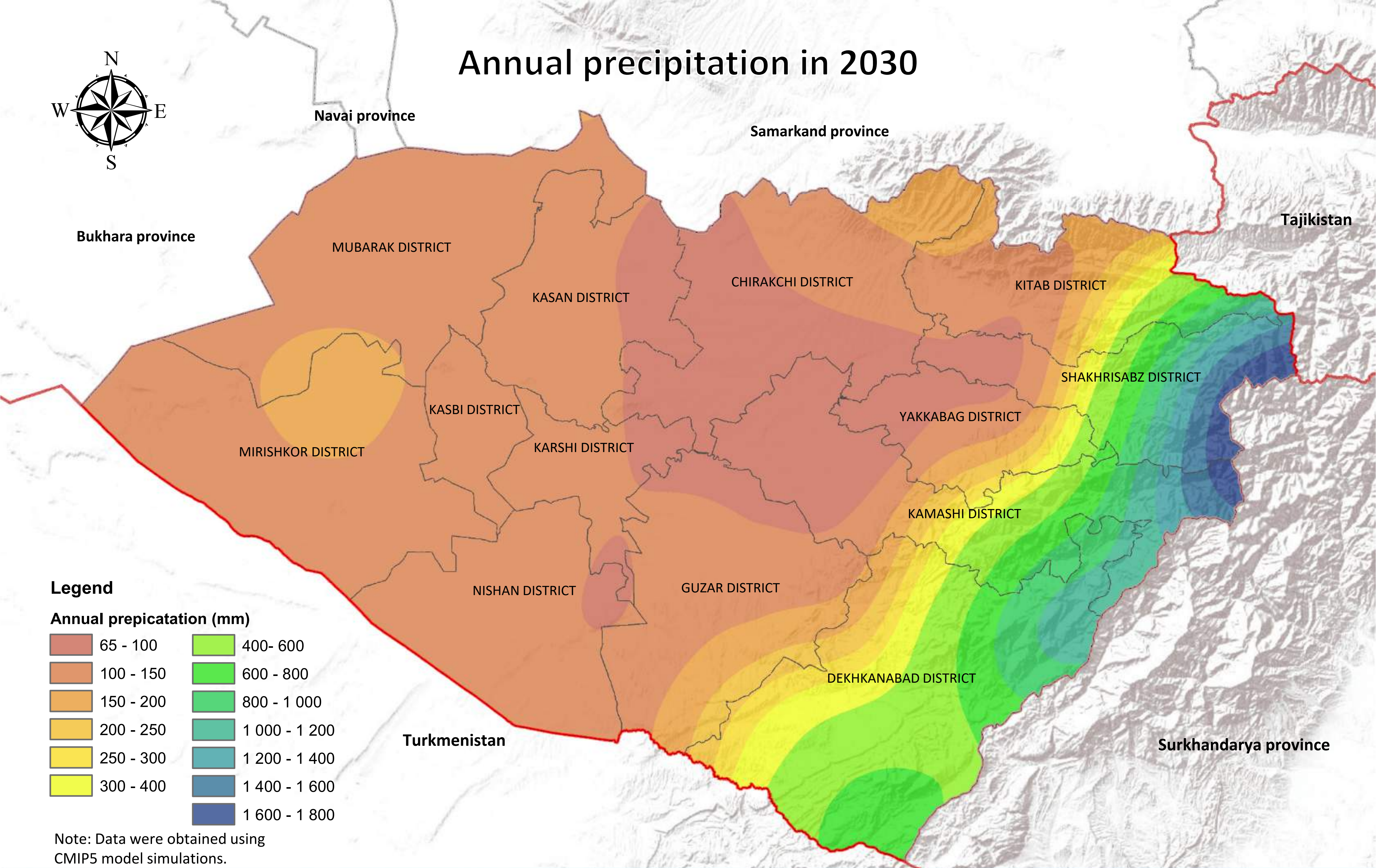
Source: IWMI, 2017


Annual average wind speed in 2050
N
W
E
S
Navai province
Samarkand province
Bukhara province
Tajikistan
MUBARAK DISTRICT
KASAN DISTRICT
CHIRAKCHI DISTRICT
KITAB DISTRICT
SHAKHRISABZ DISTRICT
YAKKABAG DISTRICT
KASBI DISTRICT
KARSHI DISTRICT
MIRISHKOR DISTRICT
KAMASHI DISTRICT
NISHAN DISTRICT
GUZAR DISTRICT
DEKHKANABAD DISTRICT
Turkmenistan
Surkhandarya province
Legend
Wind speed (m/s)
3.8 - 4.0
4.0 - 4.2
4.2 - 4.4
4.4 - 4.6
4.6 - 4.8
4.8 - 5.0
5.0 - 5.2
5.2 - 5.4
Note: Data were obtained using CMIP5 model simulations.
Source: IWMI, 2017



Source: IWMI, 2017

Annual precipitation in 2030



Note: Data were obtained using CMIP5 model simulations.

Source: IWMI, 2017

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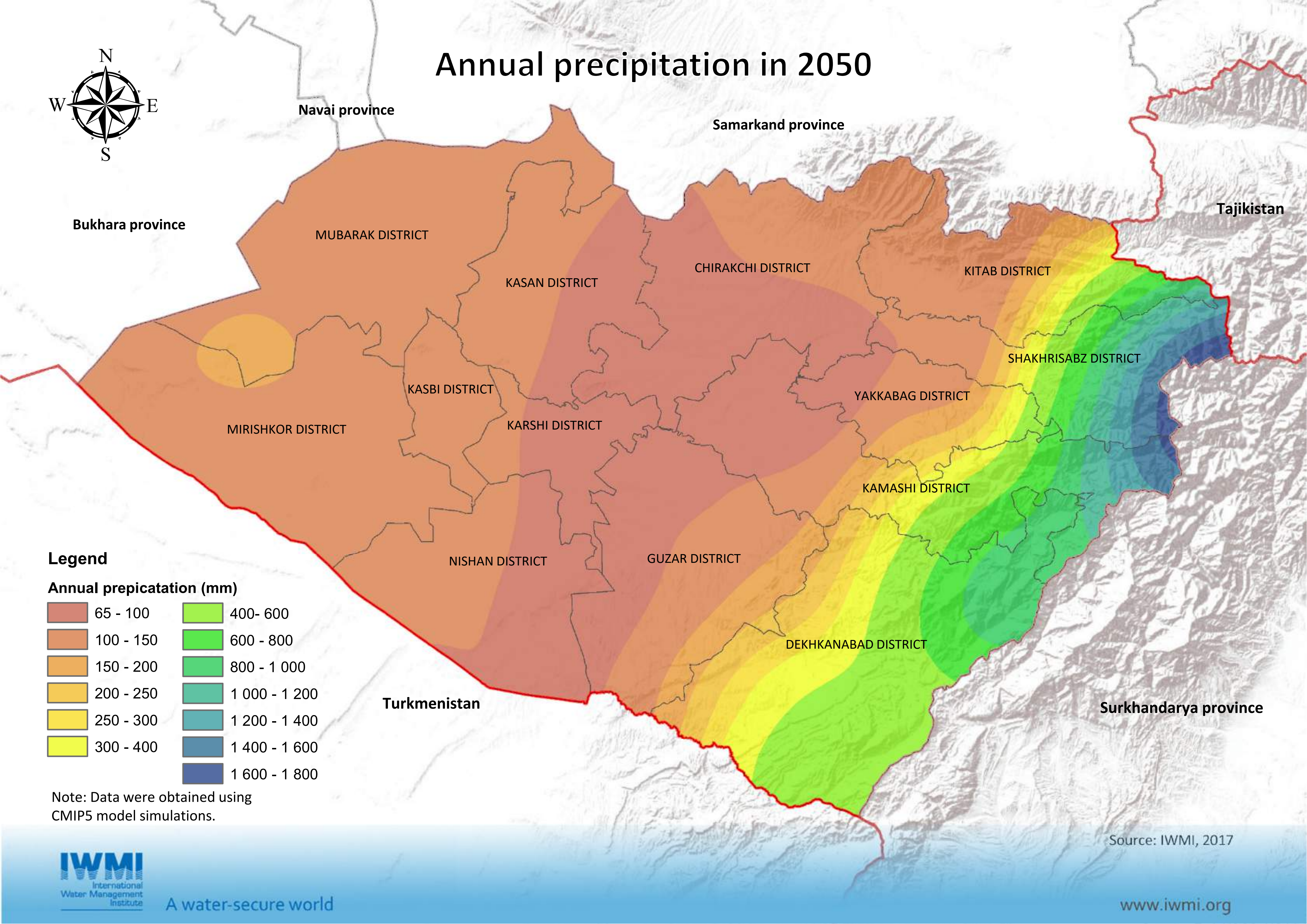
Annual precipitation in 2050
N
W
E
S
Navai province
Samarkand province
Bukhara province
Tajikistan
MUBARAK DISTRICT
KASAN DISTRICT
CHIRAKCHI DISTRICT
KITAB DISTRICT
SHAKHRISABZ DISTRICT
KASBI DISTRICT
YAKKABAG DISTRICT
MIRISHKOR DISTRICT
KARSHI DISTRICT
KAMASHI DISTRICT
NISHAN DISTRICT
GUZAR DISTRICT
DEKHKANABAD DISTRICT
Turkmenistan
Surkhandarya province
Legend
Annual prepicatation (mm)
65 - 100
100 - 150
150 - 200
200 - 250
250 - 300
300 - 400
400- 600
600 - 800
800 - 1 000
1 000 - 1 200
1 200 - 1 400
1 400 - 1 600
1 600 - 1 800
Note: Data were obtained using CMIP5 model simulations.
Source: IWMI, 2017
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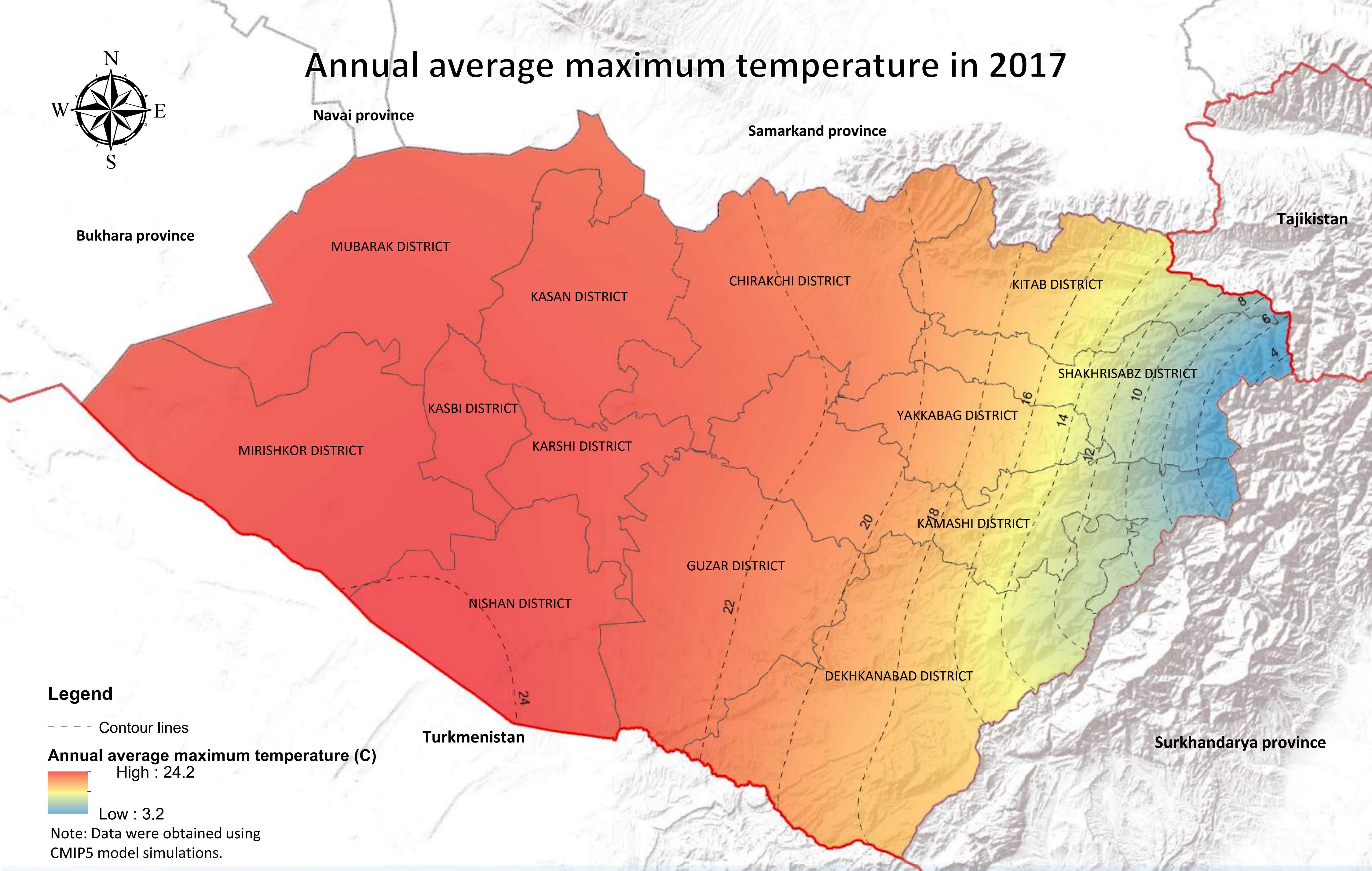
Annual average maximum temperature in 2017



Legend

- - - - Contour lines

Annual average maximum temperature (C)

High : 24.2

Low : 3.2

Note: Data were obtained using CMIP5 model simulations.

Source: IWMI, 2017

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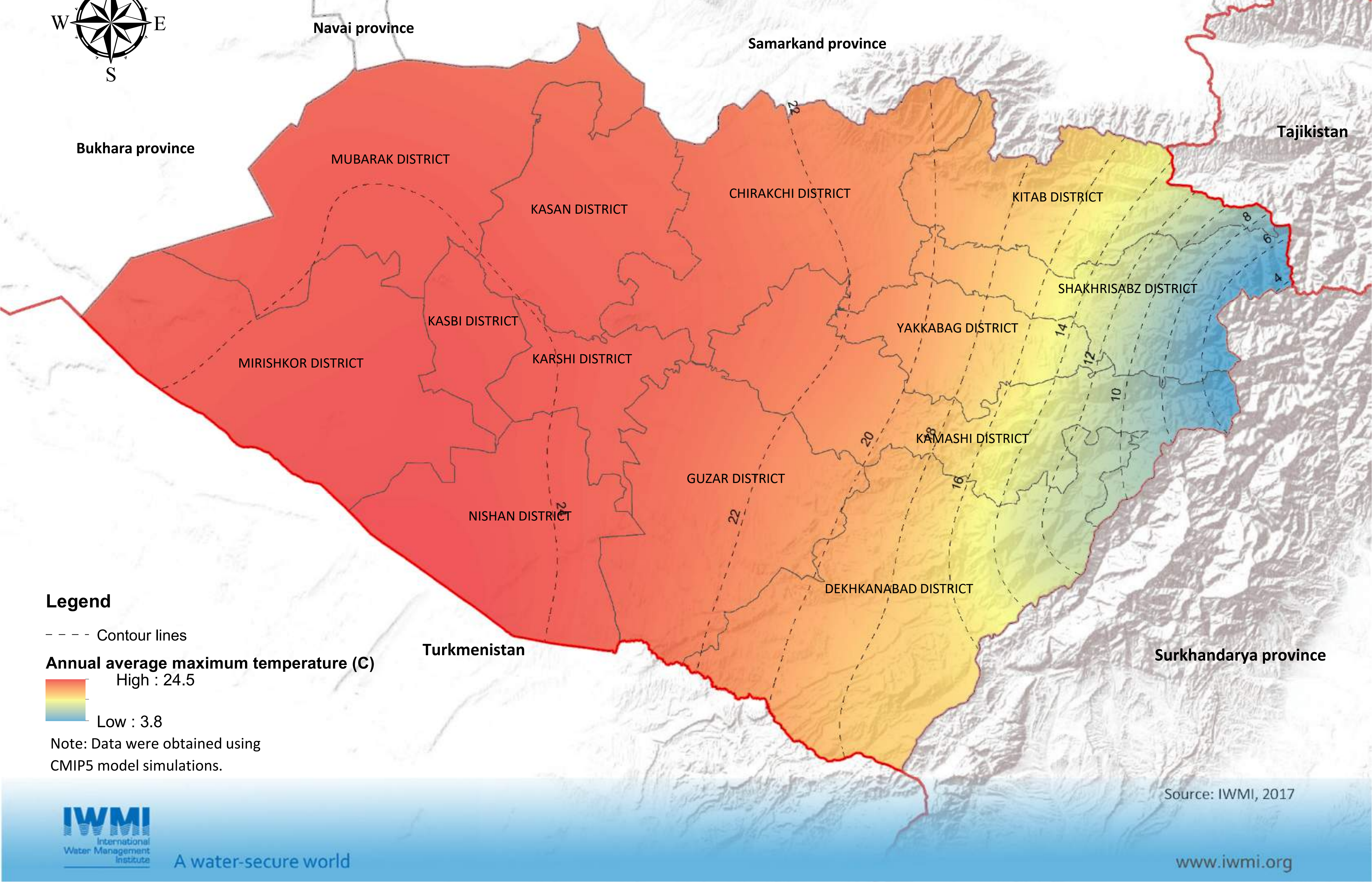
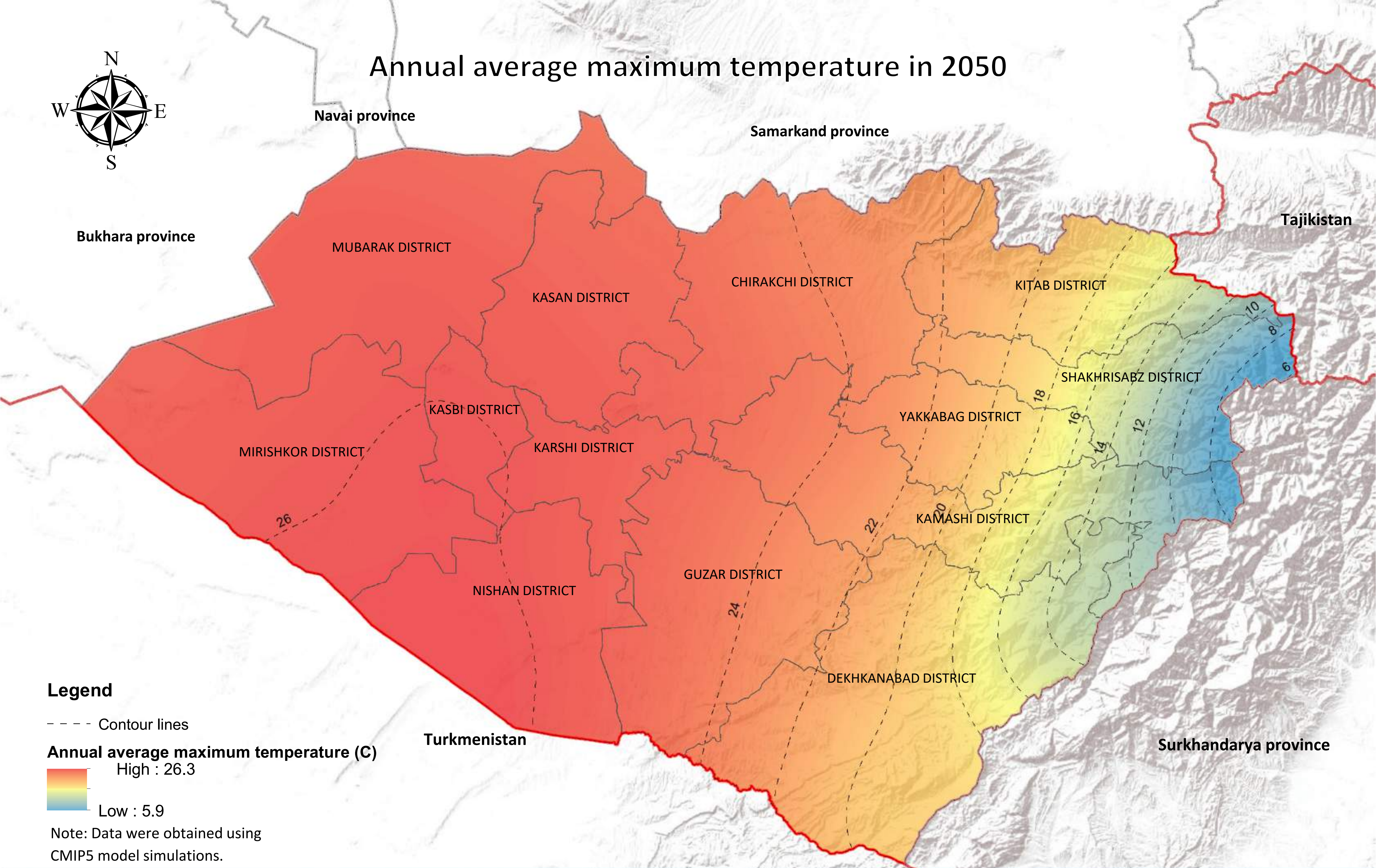
Annual average maximum temperature in 2030



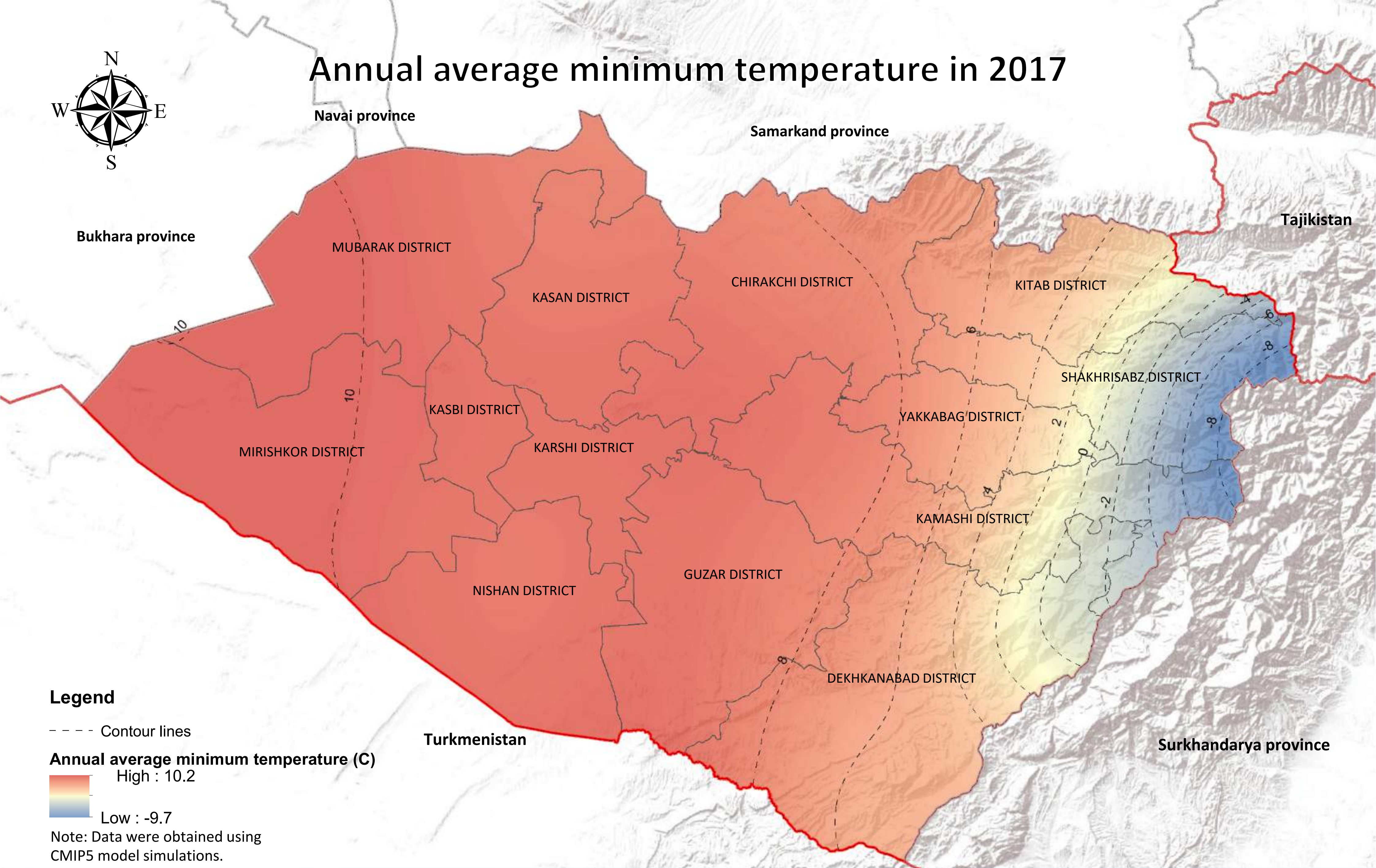
Annual average maximum temperature in 2050



Note: Data were obtained using CMIP5 model simulations.

Source: IWMI, 2017

Annual average minimum temperature in 2017



Note: Data were obtained using CMIP5 model simulations.

Source: IWMI, 2017

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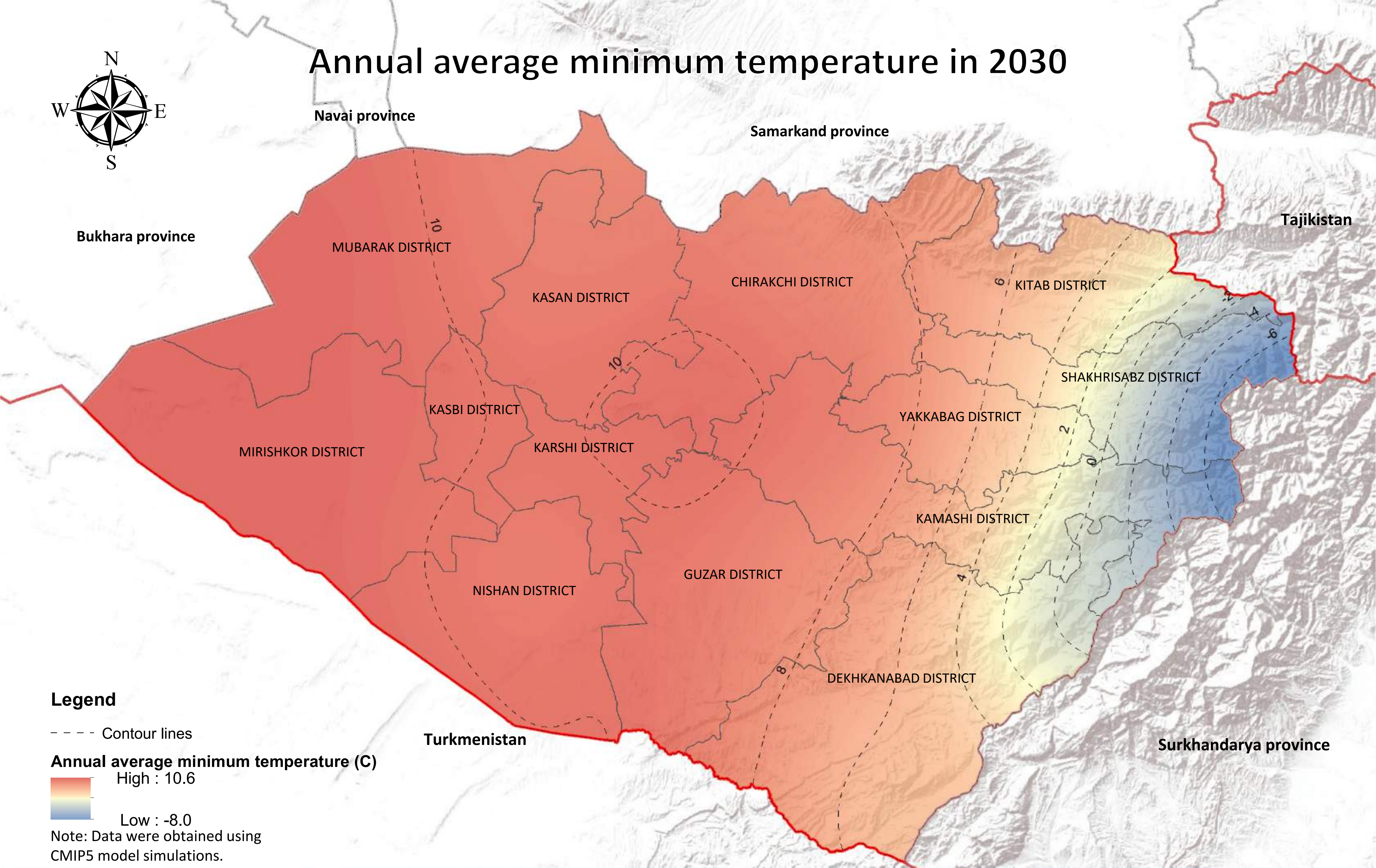
Annual average minimum temperature in 2030



Legend

- - - - Contour lines

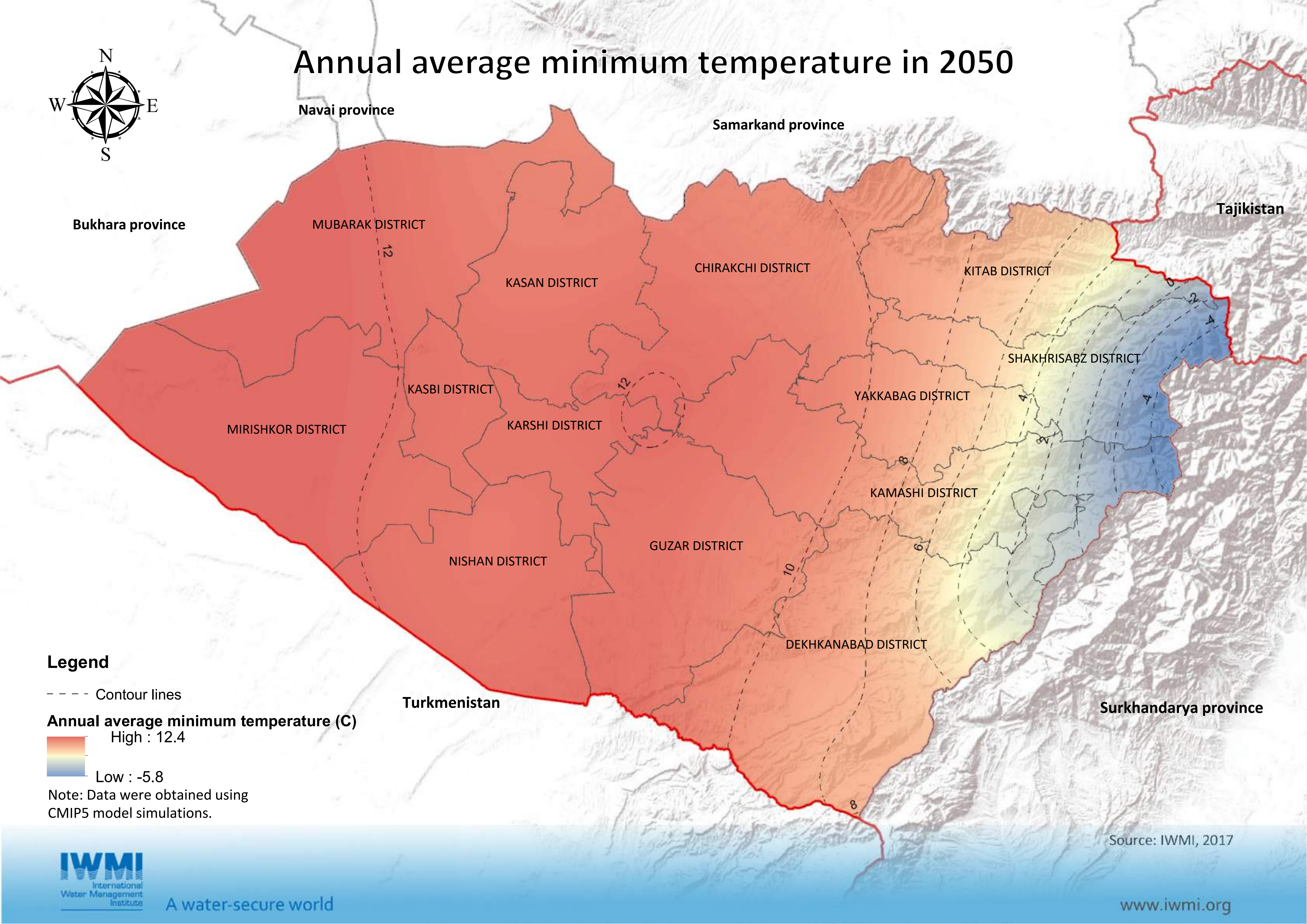
Annual average minimum temperature (C)

High : 10.6

Low : -8.0

Note: Data were obtained using CMIP5 model simulations.

Source: IWMI, 2017



Annual average minimum temperature in 2050
N
S
W
E
Navai province
Samarkand province
Bukhara province
Tajikistan
Turkmenistan
Surkhandarya province
MUBARAK DISTRICT
KASAN DISTRICT
CHIRAKCHI DISTRICT
KITAB DISTRICT
SHAKHRISABZ DISTRICT
YAKKABAG DISTRICT
KASBI DISTRICT
KARSHI DISTRICT
MIRISHKOR DISTRICT
KAMASHI DISTRICT
GUZAR DISTRICT
NISHAN DISTRICT
DEKHKANABAD DISTRICT
12
12
10
8
8
6
4
4
2
0
2
4
-4
Legend
Contour lines
Annual average minimum temperature (C)
High : 12.4
Low : -5.8
Note: Data were obtained using CMIP5 model simulations.
Source: IWMI, 2017
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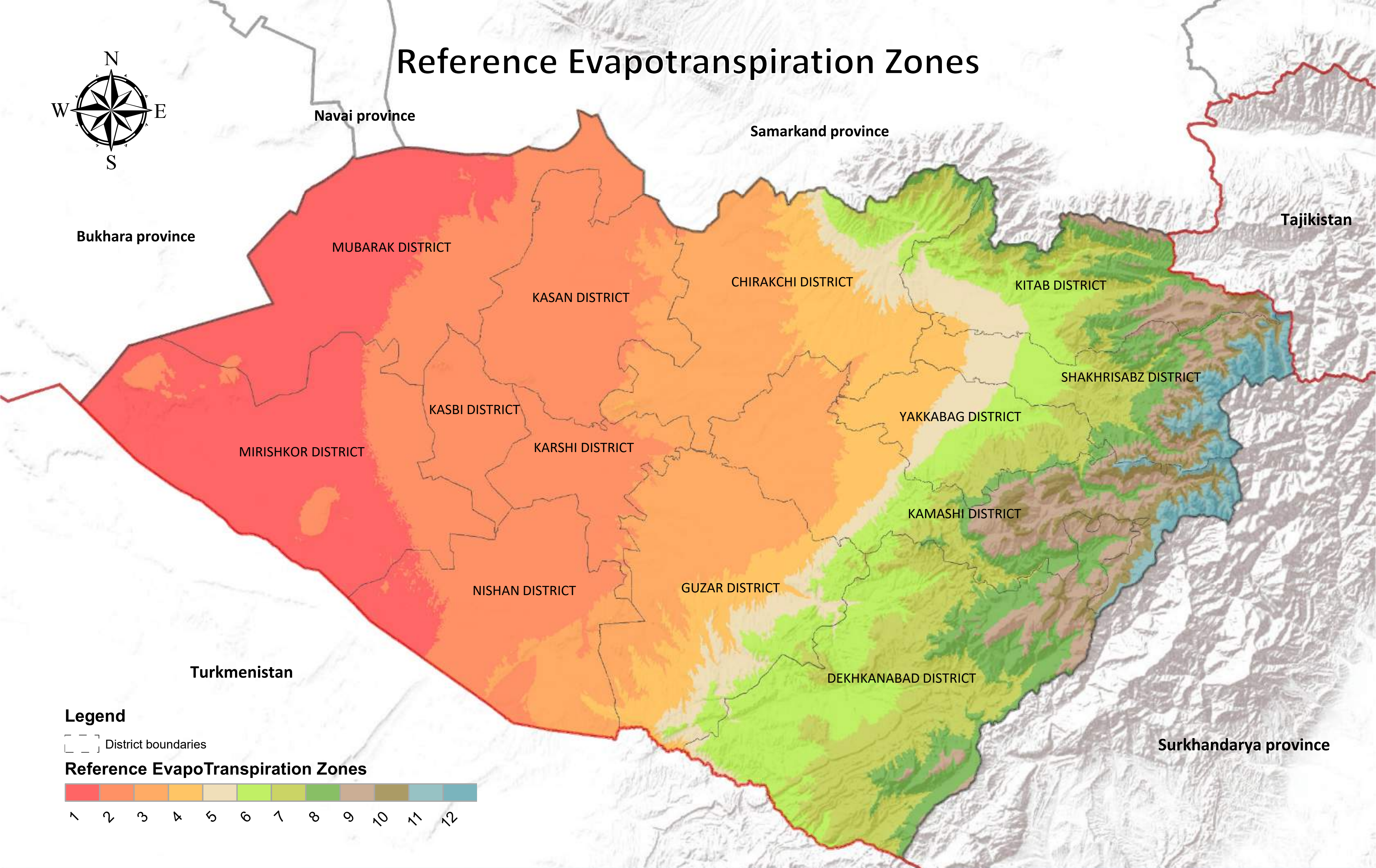
Reference Evapotranspiration Zones



Source: IWMI, 2016

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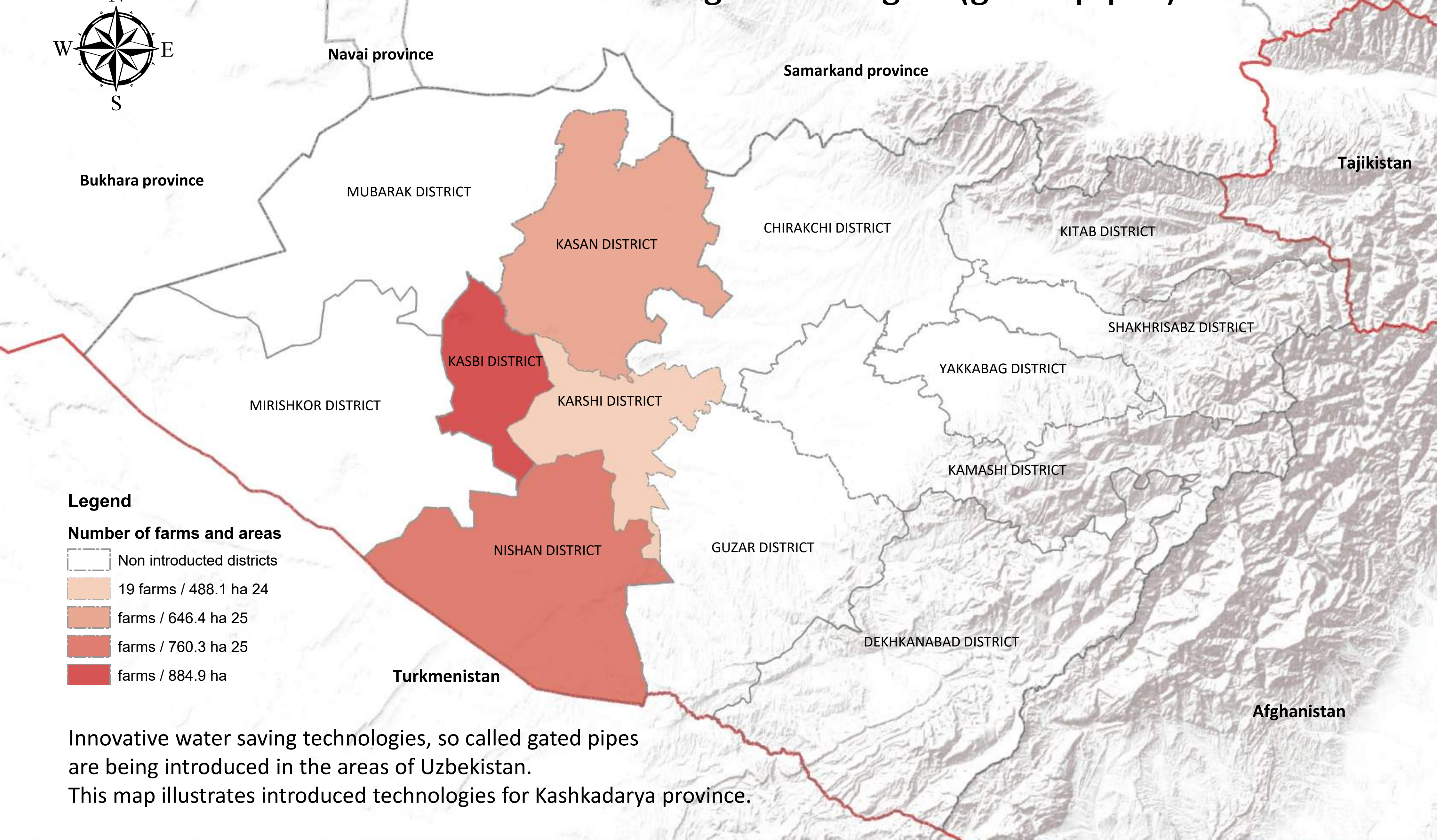
Monthly Average Reference Evapotranspiration by ETo Zone (mm/month)

Class	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Sum
1	42.9	45.0	97.9	158.2	233.7	241.8	273.8	225.4	174.9	108.2	59.2	29.9	1690.8
2	40.2	41.2	89.2	149.4	223.8	234.9	264.5	221.5	169.8	104.0	55.2	28.3	1622.1
3	36.2	36.3	76.1	132.3	208.6	224.9	250.7	214.5	162.8	98.4	48.2	26.2	1515.2
4	34.9	35.1	72.2	125.0	203.9	221.2	245.2	211.3	160.9	97.2	45.8	25.8	1478.4
5	34.7	35.0	71.7	123.1	202.9	219.9	243.6	210.2	160.8	97.2	45.4	25.8	1470.5
6	34.3	35.1	71.0	121.4	202.2	219.1	242.9	210.1	161.3	97.7	45.1	25.8	1466.0
7	34.0	35.5	70.9	118.1	201.5	217.1	240.8	208.7	161.8	98.2	44.9	25.9	1457.2
8	33.0	34.9	69.4	113.2	197.8	212.3	235.7	204.6	160.2	97.0	43.8	25.2	1427.1
9	31.3	33.4	66.2	106.4	191.3	205.3	228.5	198.8	157.1	94.5	41.9	23.8	1378.3
10	30.2	32.3	64.3	103.1	186.9	201.6	224.7	195.7	154.9	92.8	40.8	22.9	1350.2
11	29.2	31.1	62.5	100.8	182.0	198.9	222.0	193.2	152.6	91.0	39.8	22.2	1325.2
12	29.1	30.8	61.8	99.9	180.0	198.8	221.7	192.5	151.8	90.5	39.3	22.0	1318.2

Introduced innovative water saving technologies (gated pipes) in 2016



Innovative water saving technologies, so called gated pipes
are being introduced in the areas of Uzbekistan.
This map illustrates introduced technologies for Kashkadarya province.

Source: IWMI, 2016

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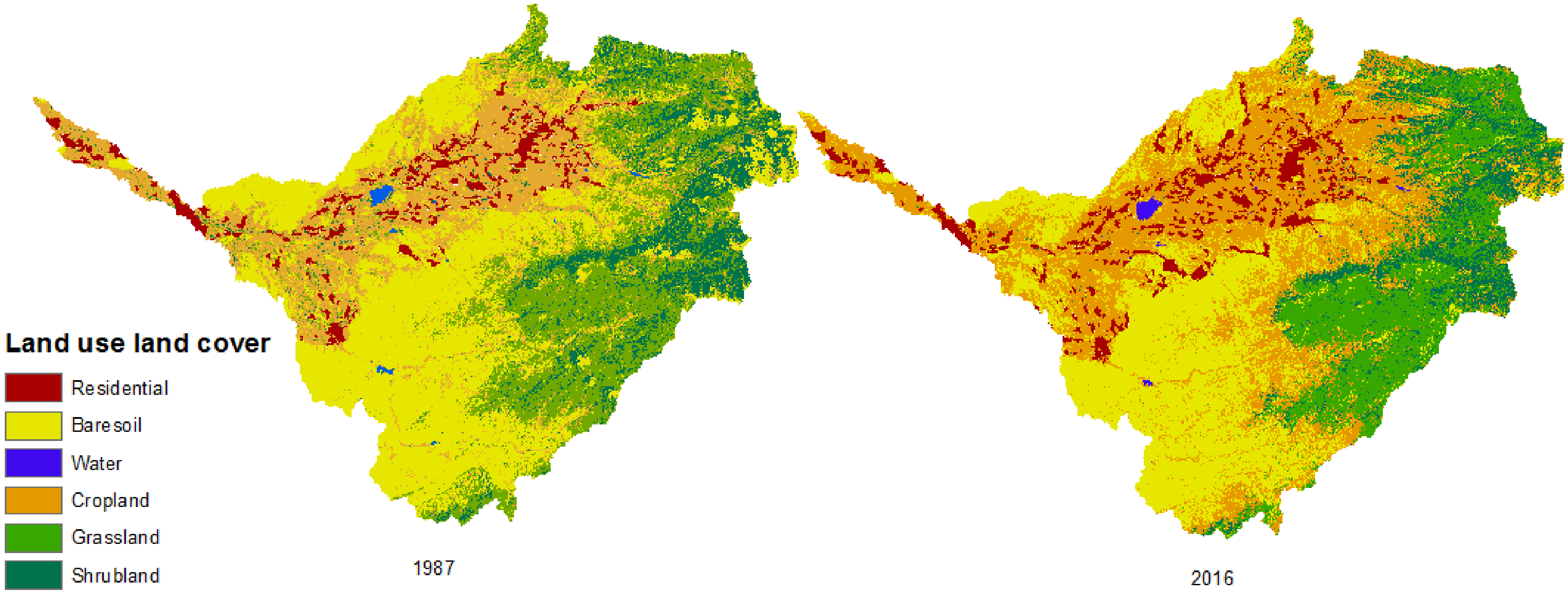
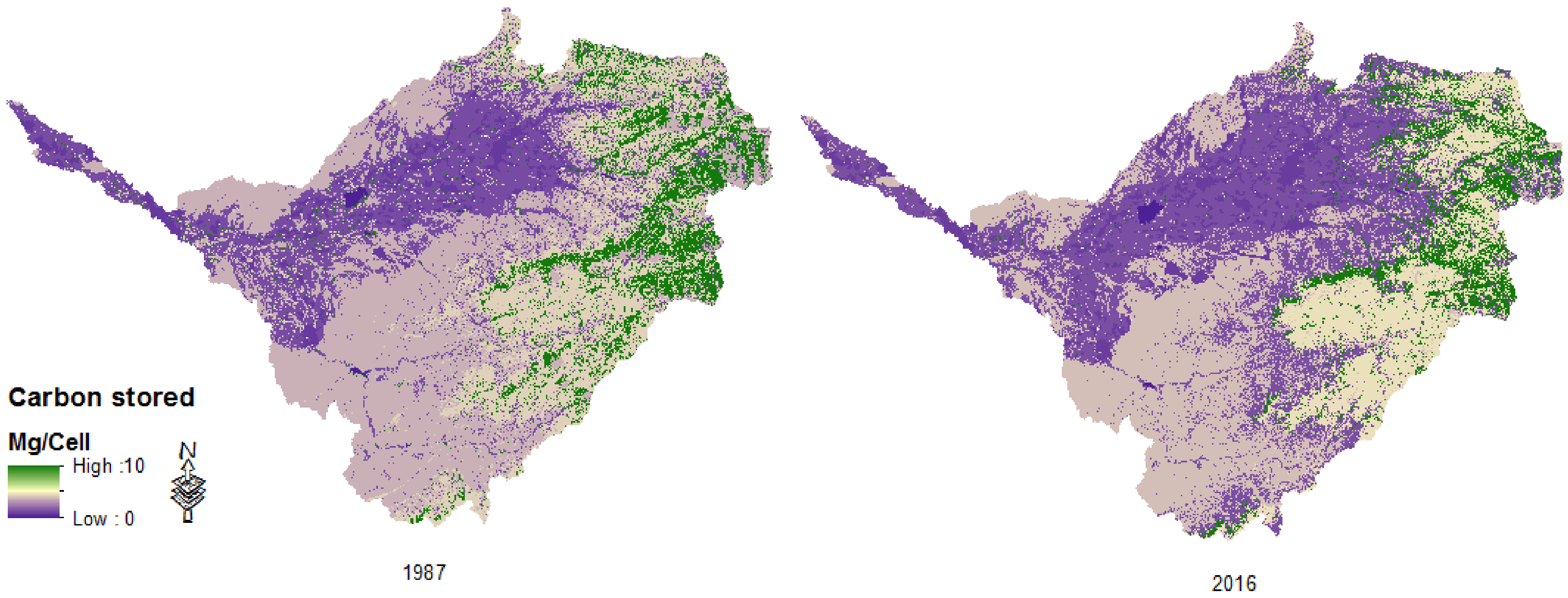
Land use land cover change map of Kashkadarya river basin for years 1987 and 2016



LULC	% LULC	% of ES in land use class			
		N retention	P retention	Carbon	Sed ret
1987					
residential	4.1	0.0	0.0	0.8	0.0
baresoil	38.5	9.5	1.2	35.2	13.7
water	0.27	0.0	0.0	0.0	0.0
cropland	23.3	11.0	20.7	10.6	5.4
grassland	23.5	70.9	74.9	25.4	35.9
shrubland	10.5	8.6	3.2	28.0	44.9
2016					
residential	6.0	0.0	0.0	1.4	0.1
baresoil	32.3	6.8	2.6	35.8	10.7
water	0.29	0.0	0.1	0.0	0.0
cropland	36.1	32.0	49.4	13.7	21.1
grassland	17.1	54.2	44.3	22.4	34.0
shrubland	8.2	7.09	3.6	26.6	34.1

Source: IWMI, 2017

Spatial distribution of carbon storage of Kashkadarya River Basin for years 1987 and 2016



Carbon cycle comprises exchange of carbon between atmosphere and biosphere. Vegetation fixes carbon from the atmosphere through photosynthesis process and produces organic matter. The organic matter is then stored in above and below ground parts of the plant which consequently transfers to dead organic pool.

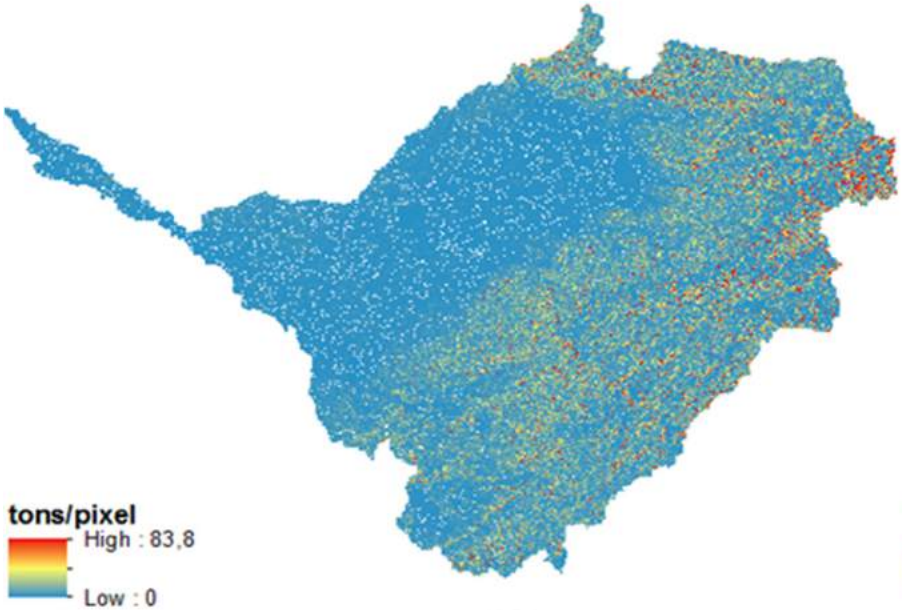
In order to find mitigation strategies of carbon emission, forest conservation, or during the selection of land management practices, it is required to estimate carbon stock pools by making carbon inventory in given area. For this reason the estimation and monitoring of current carbon pools, their changes and projection of carbon pools are necessary.

Carbon Storage and Sequestration: Climate Regulation model of InVEST shows the amount of carbon presently stored in megagramme (mg) for each grid cell. The result is sum of all four carbon pools gained according to the IPCC methodologies. The biggest carbon share comes to shrublands and grasslands. The total carbon storage capacity of Kashkadarya area in 1987 was 50 megaton (mt) of carbon, while for 2016 it was 42 mt. Decrease of ecosystem capacity on holding carbon in the thirty year period is mostly due to the increase of residential area and cropland augmentation. On average, 1 ha of land in Kashkadarya River Basin is able to hold 1000 mg of carbon.

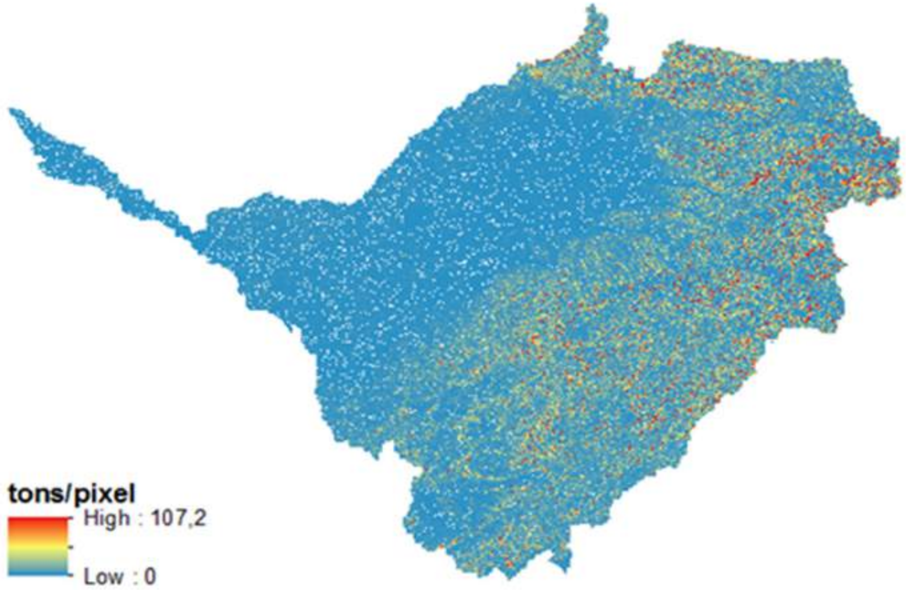
As the map shows, baresoil does not hold aptitude as much as vegetation cover by involving into only soil organic matter pools. But according to model outcomes, 32 mt of carbon is stored in soil carbon pools in the study area, which is 76 per cent of all carbon stored in the area. It was stated by Wilfred and his peers (1982) that soil organic carbon in active exchange with the atmosphere constitutes around two-thirds of the carbon in terrestrial ecosystems proving the reliability of outcome of the model. The interesting point is in that table in previous page shows that carbon holding capacity of baresoil is 35 percent which contradicts the statement given above. The plausible explanation of it is that, any land no matter what type of land management is practiced, exists soil cover and it has the capacity to hold carbon in different amounts, whereas baresoil does not have either aboveground, belowground or litter carbon pools. Consequently, soil carbon storage has the biggest capacity to hold carbon. Therefore it has 35 percent, while soil carbon pool of the area has 76 percent of total carbon holding capacity.

8 billion of carbon sink is stored in aboveground biomass pools due to the limited vegetation cover with sparse and uneven distribution over Kashkadarya River basin. Other 2 billion Mg of carbon sequestration comes to belowground and deadwood carbon pools consequently.

Spatial distribution of total potential soil loss per pixel of Kashkadarya River Basin calculated from the USLE equation for years 1987 and 2016



1987



2016

Sediment yield growth is observed in many parts of the world which consequently affects water quality and dam management (Walling, 2009). Sediment yields are strongly related to the climate, topography and land use which produce mutual non-linear relationship (Allan, 2004; Gergel et al., 2002). The sediment delivery is natural process but human activities like agriculture alter the process which in turn increases the load of sediment and brings consequences such as: reduced soil fertility which decreases water and nutrient holding capacity; increase in treatment costs for drinking water supply; reduced lake clarity diminishing the value of recreation; increase in total suspended solids impacting health and distribution of aquatic populations; increase in reservoir sedimentation diminishing reservoir performance or increasing sediment control costs; and, increase in harbor sedimentation requiring dredging to preserve harbor function.

In order to understand the complex relationship, different theoretical, empirical and physics-based models have been developed as clear information about sediment retention helps to design strategies, to reduce the sediment loads, preserve areas with high retention capacity and also target low impact areas for agricultural activities. InVEST is among those models which help to quantitatively understand the natural and human induced processes combination in sediment delivery.

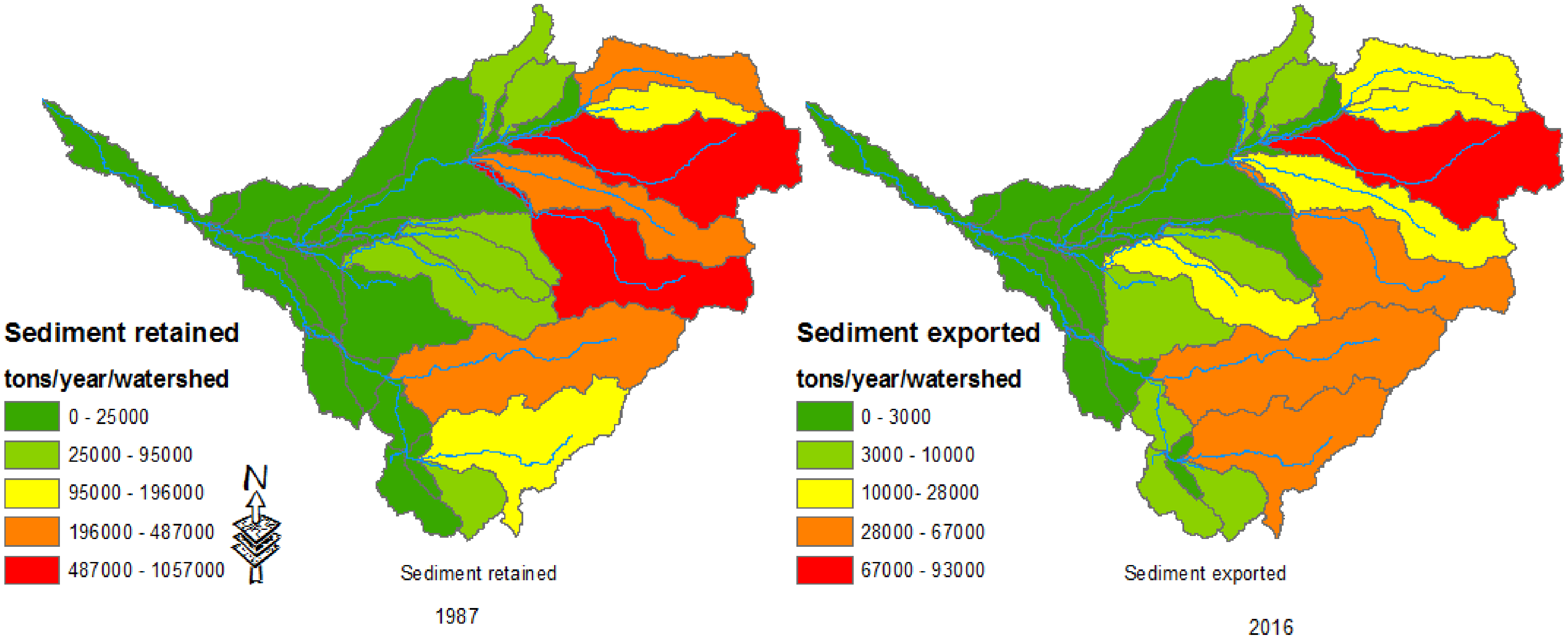
The outputs of InVEST Sediment Retention model are the sediment load delivered to the stream at a yearly basis, and also the total eroded sediment in the catchment and retained by vegetation and topographic features.

According to the InVEST Sediment Retention model, the total potential soil loss is calculated using the USLE equation. The amount of estimated sediment loss is given in tons per pixel in the map. The range of maximum sediment exportation for each cell which has size of 30 meters has increased considerably to 20 tons in two study years. Nevertheless, total soil loss is increased insignificantly from 29 to 32 billion tons between 1987 and 2016 respectively. The increase of soil loss is due to the increased residential area and agricultural area modification from natural land use types.

Moreover, the model estimated the soil loss for bare soil which means erosion potential for no vegetated cover as a separate output, and it showed that up to 336 tons of soil annually could be exported if land use type is changed or biomass is removed. This means vegetation cover of Kashkadarya River Basin is a function of decreasing erosion process by about 3 times (dividing bare soil annual soil loss, 336 tons, by current annual soil loss, 107 tons).

Source: IWMI, 2017

The amount of retained sediment load for each watershed and volume of sediment exported to the stream per watershed

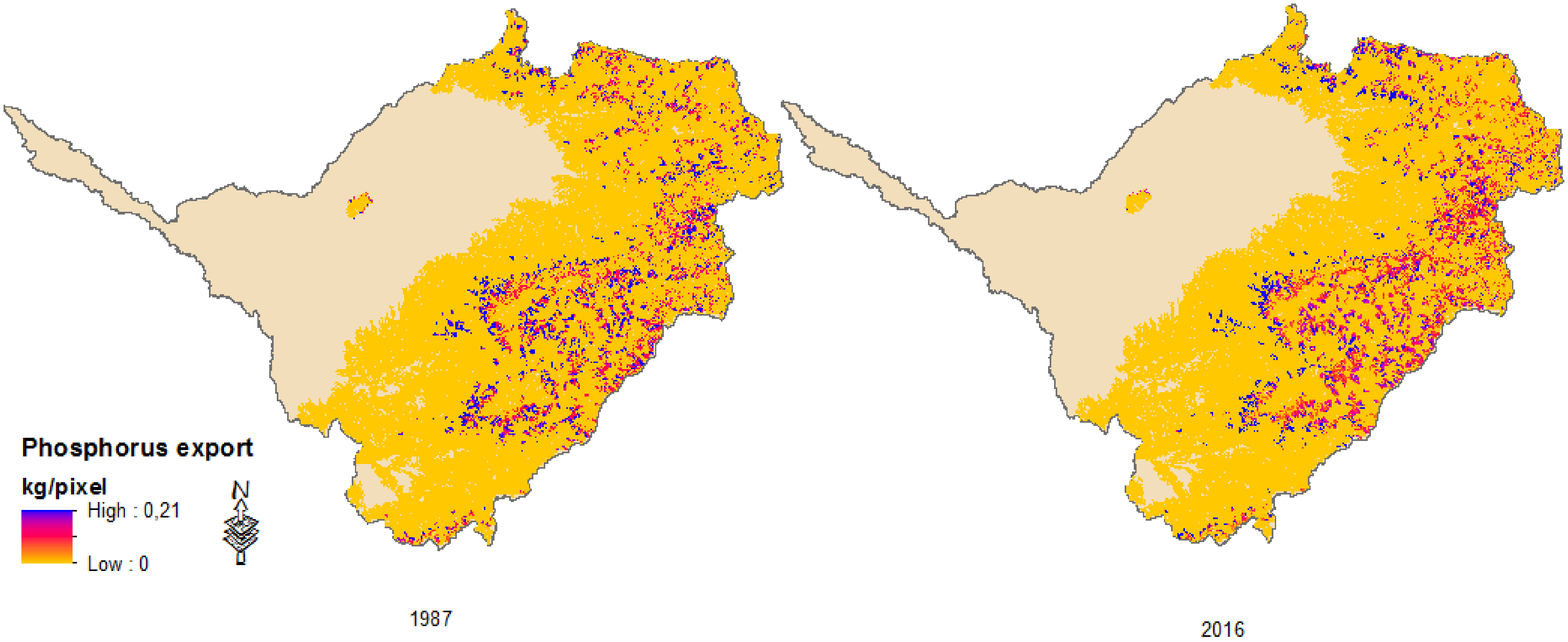


The figure shows information about soil load and movement in Kashkadarya River Basin at watershed level. Sediment exported map provides information about the quantity of total exported sediment in each watershed. Whereas, sediment retained map illustrates the difference of soil loss between suppositional watershed with no vegetation cover and current watershed sediment load delivery. According to this figure, north-eastern part of the basin watersheds holds biggest capacity to retain soil by reducing soil erosion up to 10 times.

The overall amount of sediment exported from each pixel that reaches the stream was 30 and 31 tons for years 1987 and 2016 respectively, correspondingly showing little change in the thirty-year period.

Source: IWMI, 2017

A pixel level map of phosphorus quantity load of Kashkadarya River Basin from each pixel eventually reaches the stream for years 1987 and 2016

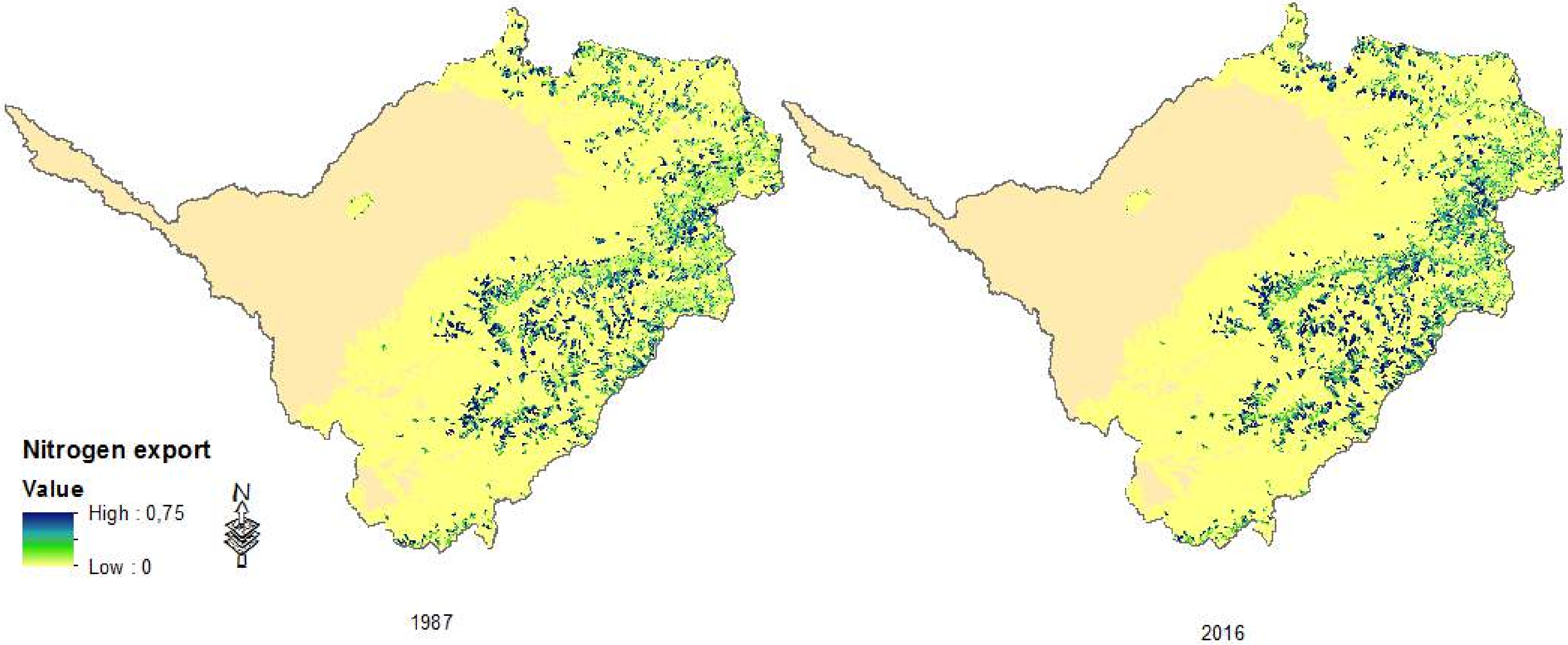


Nutrient retention model estimated a possible retained amount of phosphorus and identified the location of retained nutrient in the area. Grasslands and croplands have significant pattern of phosphorus retention in the study area.

The pixel level maps of phosphorus present how much load from each pixel ultimately reaches the stream. In total, 37 tons of phosphorus in 1987 and 57 tons in 2016 were exported. The rocketed quantity of nitrogen exported to the stream are due to the declined grasslands in the area.

Source: IWMI, 2017

A pixel level map of nitrogen quantity load of Kashkadarya River Basin from each pixel eventually reaches the stream in kg/pixel for years 1987 and 2016

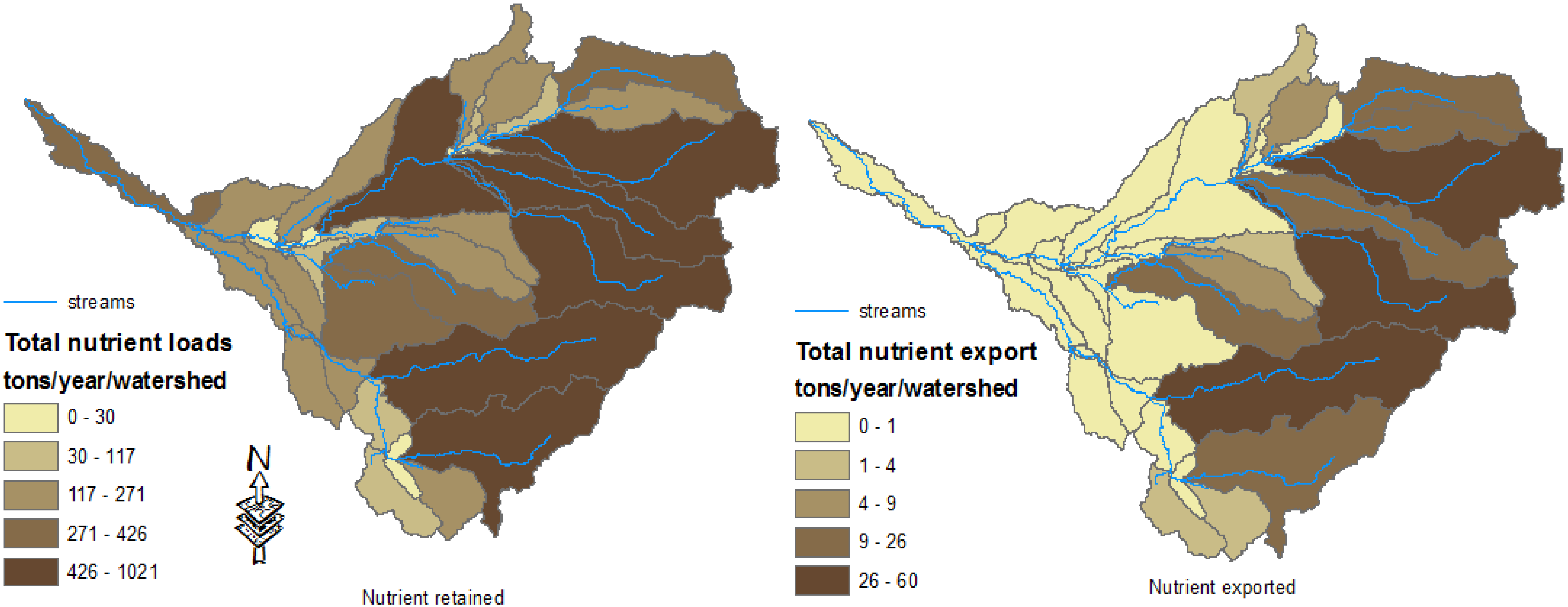


Nutrient retention model estimated a possible retained amount of nitrogen and identified the location of retained nutrient in the area. Grasslands and croplands have significant pattern of nitrogen retention in the study area.

The pixel level maps of nitrogen present how much load from each pixel ultimately reaches the stream. In total, 286 tons in 1987 and 341 tons in 2016 of nitrogen were exported. The rocketed quantity of nitrogen exported to the stream are due to the declined grasslands in the area.

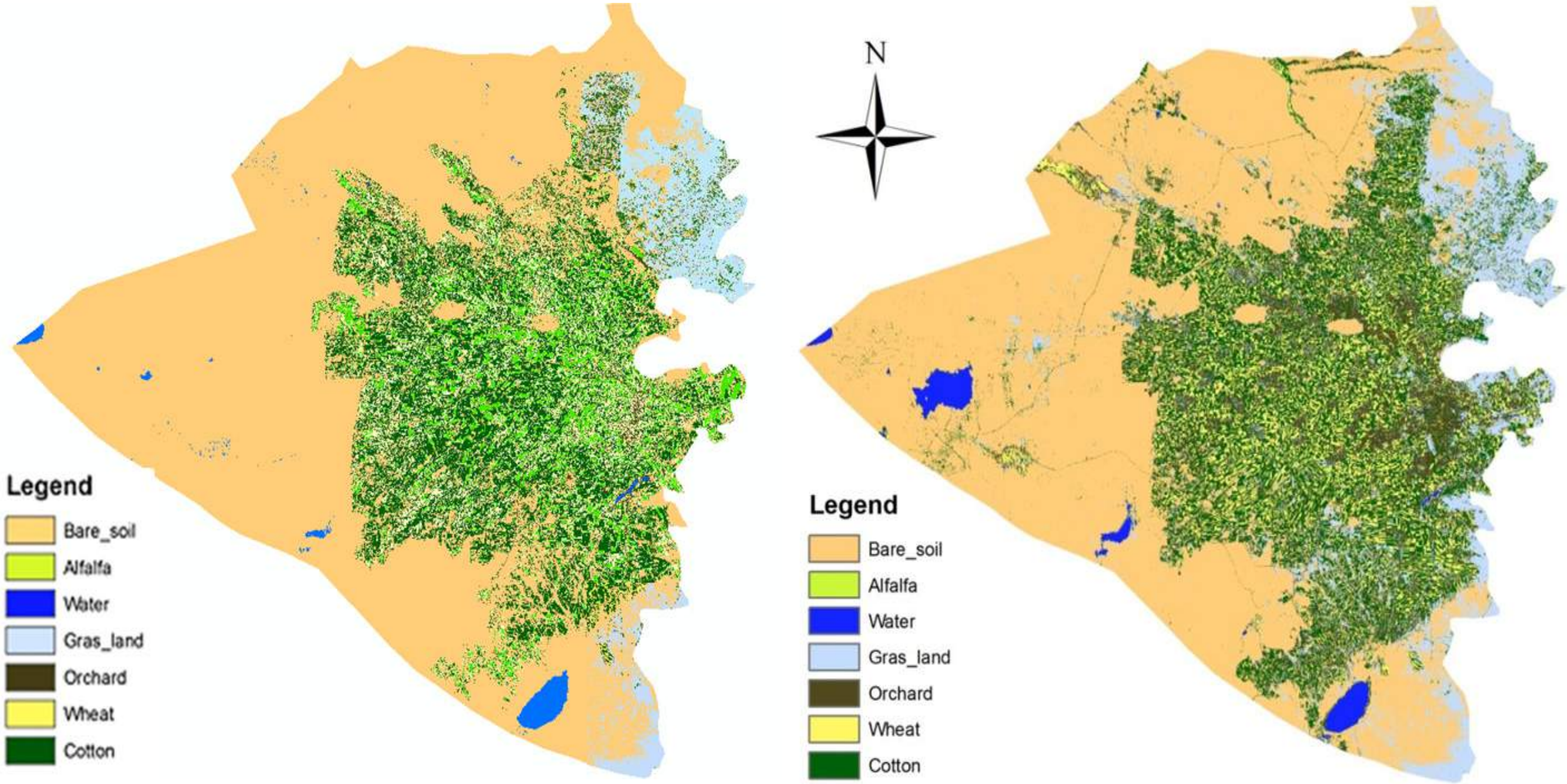
Source: IWMI, 2017

The amount of retained nutrient load for each watershed and volume of sediment exported to the stream per watershed



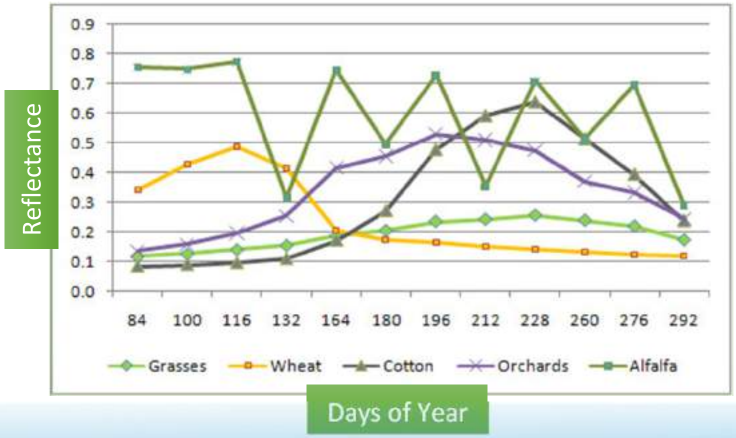
The maps above provide information about nitrogen retention capacity of the area and exported nutrient amount at watershed level. Nutrient retention is highest in eastern part of the Kashkadarya River Basin as this part has the highest elevation covered with grasslands and shrublands.

Crop type change in Karshi steppe

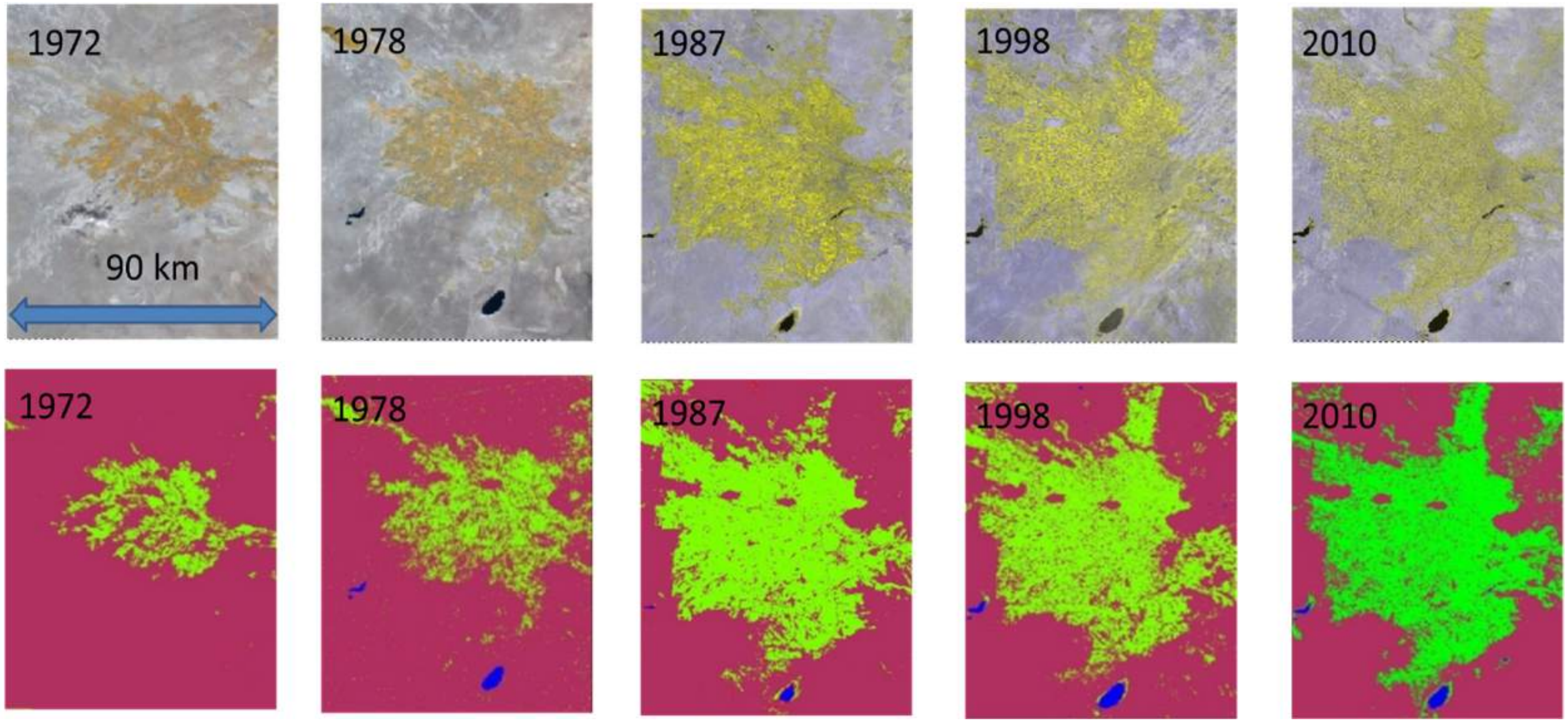


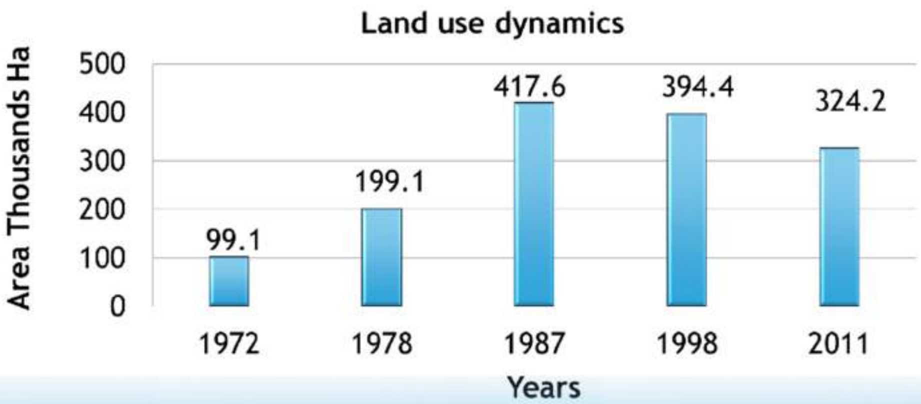
Class Names	1987		2010	
	Area (ha)	Percentage (%)	Area (ha)	Percentage (%)
Irrigated area			**Irrigated area**	
Wheat	41745	3.5	91486.4	7.64
Cotton	222876.2	18.6	136687	11.41
Orchard	23140	1.9	19325	1.61
Alfalfa	79292	6.6	19829.1	1.66
Settlement	58651	4.9	65171.43	5.44
Total irrigated	**425704.2**	**35.5**	**332498.9**	**27.76**
No irrigated			**No irrigated**	
Water area	8213	0.7	15385	1.28
Bare soil	595197.7	49.7	690043	57.60
Grass lands	169045	14.1	160036	13.36
Total no irrigated	**772455.7**	**64.5**	**865464**	**72.24**
Total irrigated, no irrigated	**1197963**	**100**	**1197963**	**100**

Vegetation indices (NDVI) of agricultural crops in Karshi Steppe



Irrigated land change in Karshi steppe





Source: IWMI, 2012

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