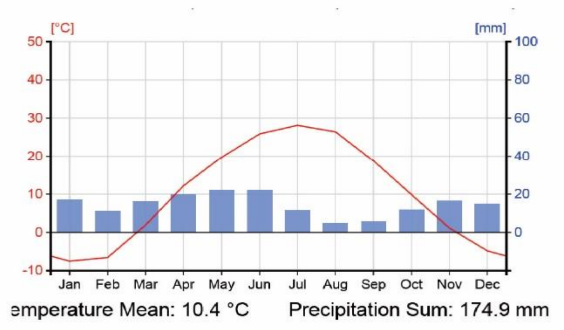
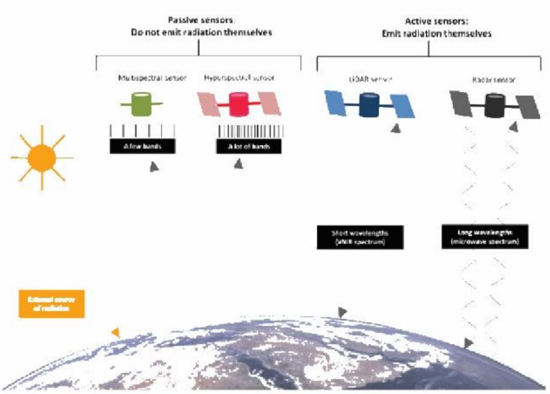
INITIATIVE ON NEXUS Gains

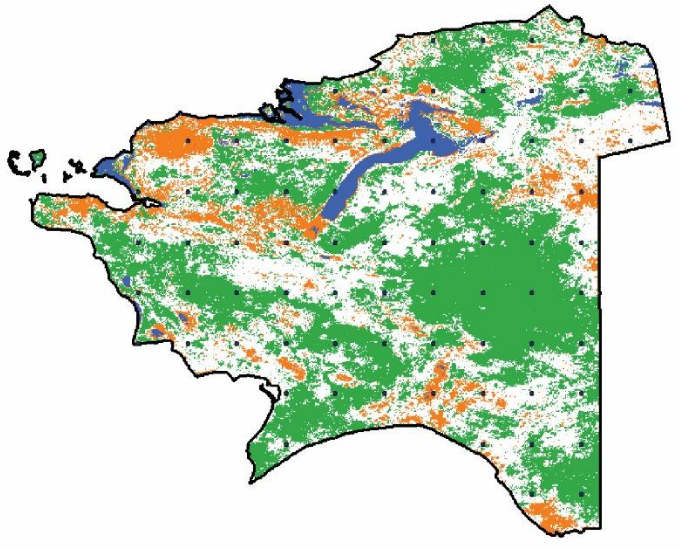
International Water Management Institute

Ecologically oriented regional development in the Aral Sea region program
Increasing water use efficiency in the Aral Sea Region

Geodatabase and Atlas: Mangistau region, Kazakhstan







Zafar Gafurov, Sarvarbek Eltazarov, Asset Yegizbayeva,
Kakhramon Djumaboev, Sherzod Zaitov and Shavkat Kenjabaev

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The German Society for International Cooperation (GIZ), as a service provider in the field of international cooperation for sustainable development and international education work, is dedicated to shaping a future worth living around the world. Having over 50 years of experience in a wide variety of areas, including economic development and employment promotion, energy and the environment, and peace and security, GIZ provides tailor-made, cost-efficient and effective services for sustainable development. GIZ has two registered offices in Germany, one in Bonn and one in Eschborn, near Frankfurt am Main. GIZ also operates from about 90 offices around the globe, some of which shared with other German development organisations.

About IWMI

The International Water Management Institute (IWMI) is an international, research-for-development organization that works with governments, policymakers, farmers, civil society, water managers, development partners and businesses to solve water problems and scale up solutions. Through partnership, IWMI combines research on the sustainable use of water and land resources, knowledge services and products with capacity strengthening, dialogue and policy analysis to support implementation of water management solutions for agriculture, ecosystems, climate change and inclusive economic growth. Headquartered in Colombo, Sri Lanka, IWMI is a Research Center of CGIAR with offices in 15 countries and a global network of scientists operating in more than 55 countries.

About the "Ecologically oriented regional development in the Aral Sea region program"

Since 2020, the project has been supporting two Central Asian states (Kazakhstan and Uzbekistan) to improve the capacity of organisations and individuals, with the aim of enabling them to make climate-adapted and ecologically oriented investment decisions. For further details about the project, visit: https://www.giz.de/en/worldwide/93488.html.

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International Water Management Institute
www.iwmi.org

CONTENT

The authors:

Zafar Gafurov is a Researcher (Remote Sensing and GIS Specialist) at Central Asia Office of the International Water Management Institute (IWMI), Tashkent, Uzbekistan.

Sarvarbek Eltazarov is a Regional Consultant at Central Asia Office of the International Water Management Institute (IWMI), Tashkent, Uzbekistan

Asset Yegizbayeva Researcher and regional consultant on remote sensing and GIS at Central Asia Office of the International Water Management Institute (IWMI), Tashkent, Uzbekistan.

Kakhramon Djumaboev is a Researcher / Project Leader (Water Resource Management Specialist) at Central Asia Office of the International Water Management Institute (IWMI), Tashkent, Uzbekistan.

Sherzod Zaitov is an intern at Central Asia Office of the International Water Management Institute (IWMI), Tashkent, Uzbekistan.

Shavkat Kenjabaev is a National Researcher (Water Resources Management Specialist) at Central Asia Office of the International Water Management Institute (IWMI), Tashkent, Uzbekistan.

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/ spatial databases / atlases / digital elevation models / maps / satellite imagery / arid zones / population dynamics / urban areas / rural areas / land cover / land use / soil types / soil organic carbon / water resources / water supply / pumps / water demand / water-use efficiency / climate change / meteorological stations / precipitation / temperature / evapotranspiration / geographical information systems / remote sensing / transport / Kazakhstan /

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Acknowledgments

Geodatabase and Atlas: Mangistau, Kazakhstan is based on data and information generated and collected within the framework of the GIZ Program “Ecologically oriented regional development in the Aral Sea region”. Data were also obtained from published and grey literature as well as spatial analyses carried out using publicly available sources. The authors would like to thank local project partners in Mangistau for their valuable inputs and feedback when preparing the material.

International Water Management Institute

This Geodatabase and Atlas was put together within the framework of activities implemented under the GIZ Program “Ecologically oriented regional development in the Aral Sea region” as part of the project “Increasing water use efficiency in the Aral Sea Region” implemented by the International Water Management Institute (IWMI) in collaboration with GIZ and local partners.

CGIAR INITIATIVE ON NEXUS Gains

This work is mapped to the CGIAR Initiative on NEXUS Gains, which is grateful for the support of CGIAR Trust Fund contributors (www.cgiar.org/funders).

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Geodatabase and Atlas

Importance Geodatabase and Atlas

The information systems aimed at data and information management are becoming increasingly important with reference to the processes of decision making and strategic thinking in a newly emergent competitive economy setting. In addition to digital data types utilized in information systems, geospatial data have advanced significantly in recent years. Not only do these data include the geographic location of particular items on the planet, they also specify their shape and size. Spatial data including digital maps are the core component of a GIS. In order to help decision makers with the planning, design and prioritization of investment plans, these data are materialized in the form of files that are compiled into a single database.

Introduction

This Geodatabase and Atlas was developed by the International Water Management Institute (IWMI) in collaboration with regional partners as part of project activities under the GIZ project "Ecologically oriented regional development in the Aral Sea region".

Capacity-building of micro-, small- and medium-sized enterprises as well as ministries and state agencies is one of the primary focuses of the project in order to enable their employees to make climate-adaptive and environmentally oriented investment decisions. Modern satellite imagery and technologies is one of the areas that create new opportunities for agricultural, forestry and water sector professionals to improve their skills and expertise in regional spatial planning. For instance, remote sensing techniques can be instrumental in identifying environmental or climate-related industrial risks and cases of degradation for targeted improvements at an early stage.

Data Accuracy and Reliability

This Atlas was created using open source GIS, remote sensing and other relevant information including databases, maps, research, analyses etc. publicly available from renowned international agencies, research organizations and projects.

Availability and Accessibility

The Atlas can be obtained in digital form for use by external parties. When using the Atlas, the authors and the institute should be credited.

Software Employed

This Atlas and the associated maps were created on a computer machine running Windows 10 Professional and using ArcGIS, QGIS and 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 the only software that allows making use of the map package and associated geodatabase.

Aral Sea Basin

The Aral Sea, located in the Turan plain of Central Asia and once the fourth-largest inland sea in the world, has undergone many changes. Two major transboundary rivers, the Amu Darya and the Syr Darya, feed the Aral Sea. Their combined basin boundaries, which largely define the Aral Sea basin, cover a total area of 1.9 million km^2 (Xenarios et al. 2019) and extend over six countries: Kazakhstan, Turkmenistan, Uzbekistan, Afghanistan, Tajikistan and the Kyrgyz Republic. About 35 million people, two thirds of the combined population of these countries, live in the Aral Sea basin. Before 1960, about 60 billion cubic meters (BCM) (Xenarios et al. 2019) of water reached the sea annually. Today, the inflow of water has declined to 5-20 BCM annually and as a result, the level of water in the Aral Sea has dropped by almost 20 meters (m) and its area shrunk by two-thirds, from 67,000 km^2 in 1960 to 20,000 km^2 at present (Xenarios et al. 2019). The table in the following page provides some key features of the Aral Sea basin.

Table Key information on Aral sea basin, surface area and renewable surface water resources by basin countries

Country	Surface area			Renewable surface water resources			
	km^2	% Aral sea basin	% Country area	Amudarya (km^3)	Syrdarya (km^3)	Aral sea basin (km^3)	Aral sea basin (%)
Afghanistan	234800	12	36	6.18		6.18	5.3
Kazakhstan	540000	28	20		4.50	4.50	3.9
Kyrgyzstan	117500	6	59	1.93	27.25	29.18	25.2
Tajikistan	141670	7	99	62.90	0.40	63.30	54.8
Turkmenistan	466600	24	96	0.98		0.98	0.8
Uzbekistan	447400	23	100	4.70	4.84	9.54	8.3
Total	**1947970**	**100.0**		**76.69**	**36.99**	**113.68**	**98.3**
Aral sea basin				78.46	37.14	115.60	100.00

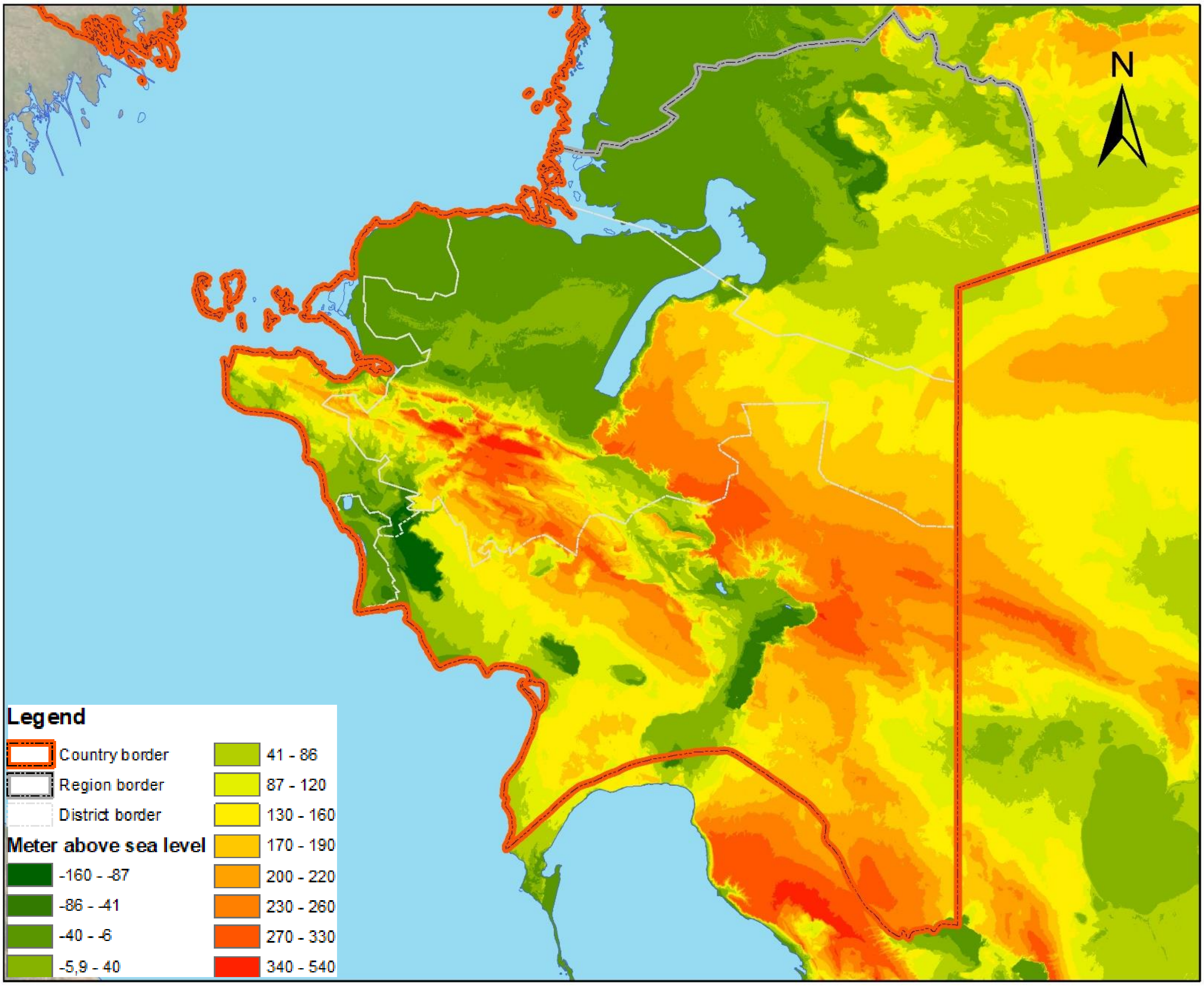
Source: FAO, 2003.

At present, the biggest challenges for the water sector in the region come from weak decision-making capacities of state water management organizations, and un-coordinated and competing interests of different stakeholders and public sectors across all levels of water management. These problems are the root causes resulting in bottlenecks and failures in implementing integrated water management approaches at river basin scale. Current water systems are in transformation, having the attributes of both past and present systems. However, an effective water administration needs to tackle both supply and demand needs, taking care of both the developing economy and the degraded environment (Xenarios et al. 2019).

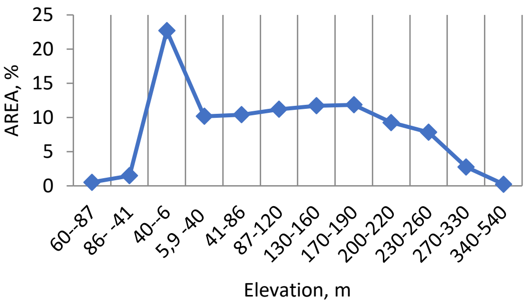
Satellite view of study area

Mangystau, a region in southwest Kazakhstan, boasts diverse landscapes, including the Caspian Shore, plateaus (like Usturt and Mangyshlak), mountains (Aktau and Karatau), and desert expanses. These varying terrains create a captivating labyrinth adorned with colorful sediment layers. Otpan Mountain stands as the highest peak at 556 meters, while the Karagie cavity plunges 132 meters below sea level as the lowest point. The region experiences continental weather, characterized by cold winters and mild summers. January averages -3°C (27°F), while July brings warmth at +26°C (79°F). Rainfall is scant, averaging 150 millimeters annually. Mangystau, with its capital Aktau, is a vital region, known for its significant Caspian coastline and its role in Kazakhstan's petroleum industry. Its 2021 population was approximately 736,795.

Digital elevation model



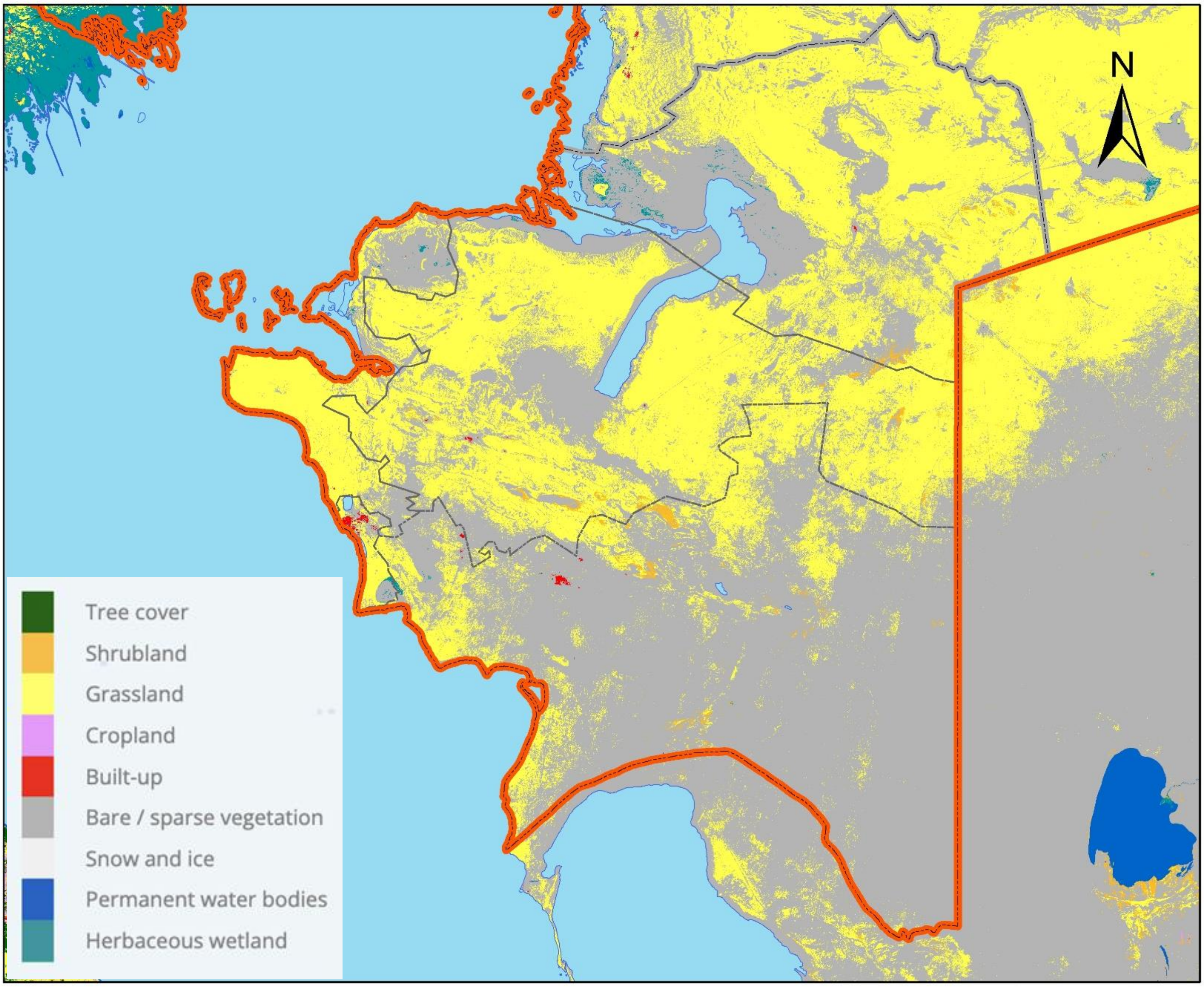
Max Elevation	540 meters
Min Elevation	-160 meters
Mean Elevation	96 meters
Mean Slope	2 degrees



The digital elevation model of Magystau region, Kazakhstan has been produced using the publicly available The Shuttle Radar Topography Mission (SRTM) digital elevation dataset. SRTM was originally produced to provide consistent, high-quality elevation data at near global scope. This version of the SRTM digital elevation data has been processed to fill data voids, and to facilitate its ease of use.
SRTM was originally produced to provide consistent, high-quality elevation data at near global scope. This version of the SRTM digital elevation data has been processed to fill data voids, and to facilitate its ease of use.

Source: Farr et al. 2007.

Land cover and use map



Source: ESA WorldCover product (Zanaga et al. 2021).

Class name	Area(%)
Tree cover	0,00
Shrubland	1,25
Grassland	42,83
Cropland	0,01
Built-up	0,12
Bare / sparse vegetation	54,31
Permanent water bodies	0,60
Herbaceous wetland	0,00

Total land area is 16564200 hectares. Of these is no irrigated agricultural area, is 0.01 %. Pasture area for livestock is 43 %, the region mostly covered by bare/sparse vegetated land - 54 %.

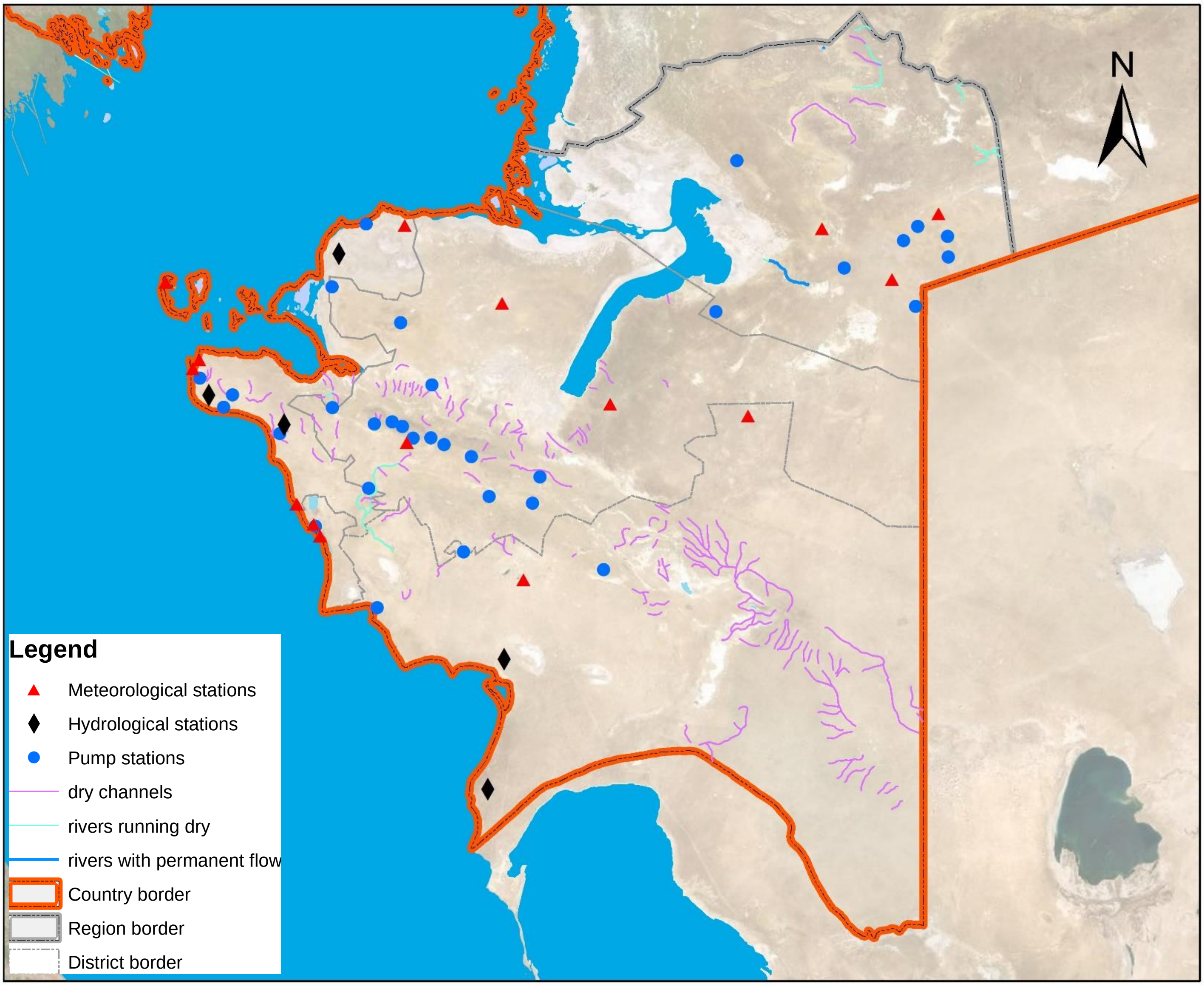
The European Space Agency (ESA) WorldCover product provides a global land cover map for 2020 at 10 m resolution based on Sentinel-1 and Sentinel-2 data. The WorldCover product comes with 11 land cover classes and has been generated in the framework of the ESA WorldCover project, part of the 5th Earth Observation Envelope Programme (EOEP-5) of the Europea

Water bodies

Mangystau region is characterized by its arid and dry climate, devoid of significant river flow. This arid landscape poses a substantial challenge when it comes to providing an adequate supply of drinking water to the region's population. Water resources are notably scarce, and this scarcity represents a critical issue for the area. The primary demand for water is centered around the urban hubs of Aktau and Zhanaozen, along with their adjacent population centers.

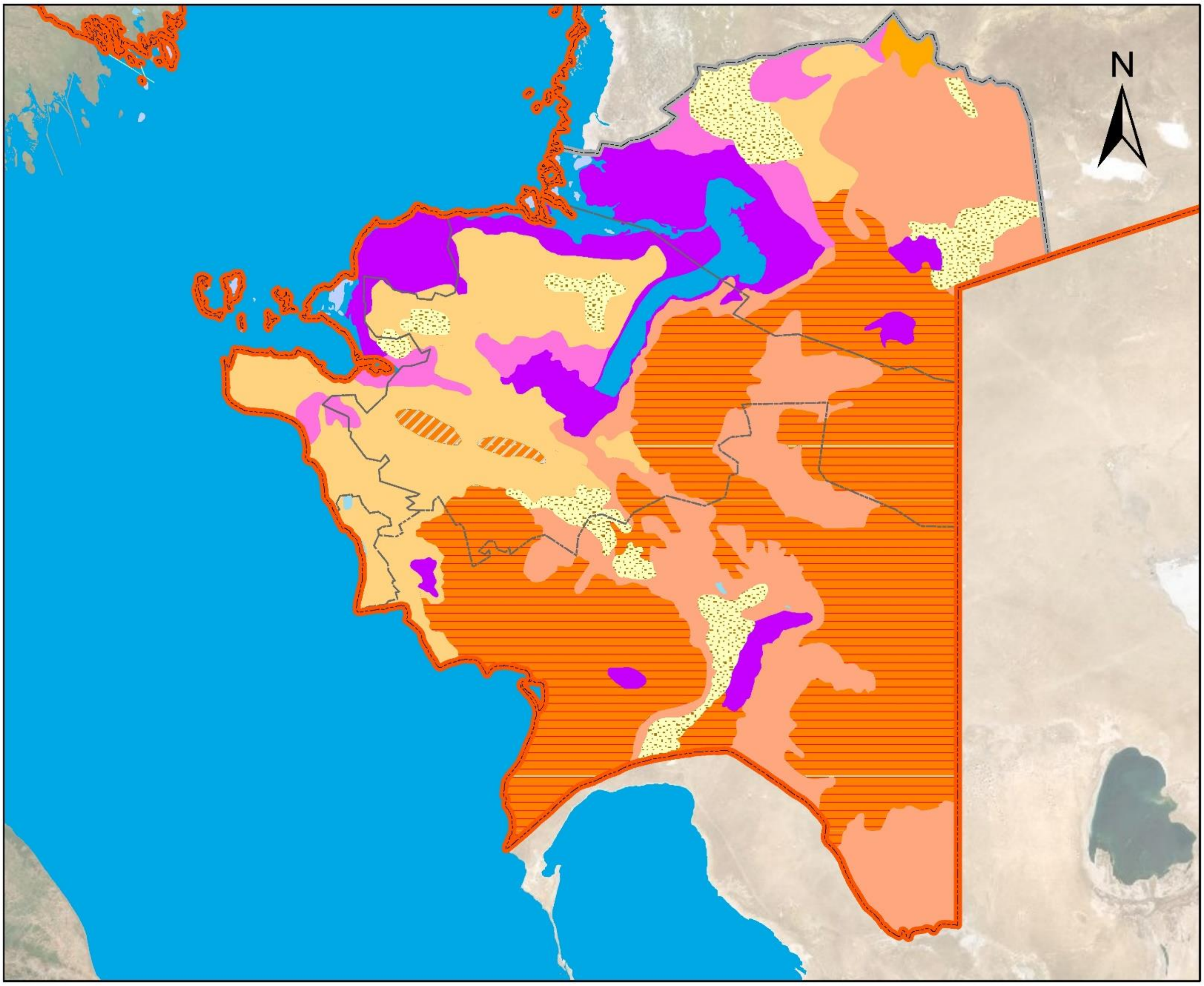
Meeting the water needs of these cities and their surroundings is a priority due to their sizable populations. The arid nature of the region necessitates careful management of the limited water resources available. This includes implementing conservation measures, exploring alternative water sources, and investing in infrastructure to ensure a sustainable and reliable supply of drinking water for the residents of Mangystau. The challenge of water scarcity underscores the importance of efficient water management and the development of innovative solutions to address this pressing issue.

Pump stations and hydro-meteo stations



The map illustrates the locations of pump stations and hydro-meteo stations within the region. Notably, water intake for irrigation is minimal, and irrigation relies heavily on pumping mechanisms. In this arid environment, water availability holds paramount significance for the livelihoods of the rural population. These communities depend on irrigation for sustenance, and the effective operation of pump stations is pivotal in ensuring their agricultural productivity. Hydro-meteo stations play a vital role in monitoring and managing water resources, helping to optimize water usage. In a region where water is a precious resource, the reliable supply of water through pumping infrastructure is indispensable for the well-being and prosperity of rural communities.

Main soil types

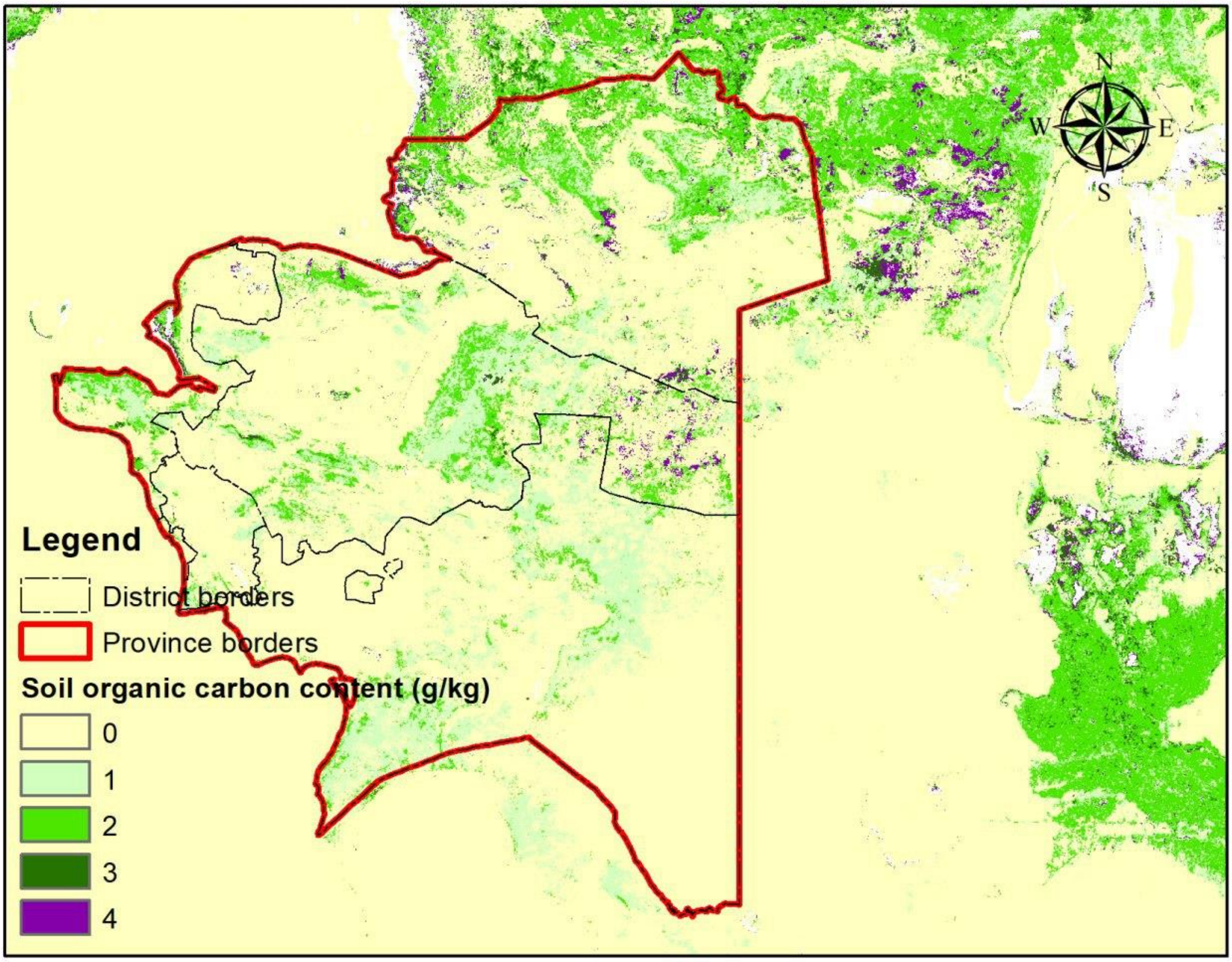


Source: THE NATIONAL ATLAS OF THE REPUBLIC OF KAZAKHSTAN, 2010 (https://ingeo.kz/?p=3643&lang=en)

Legend

- Mountain brown soils
- Desert sands
- Continental solonchaks
- Solonetze
- Grey-brown desert solonetzic soils
- Gray brown desert soils
- Light brown desert soils
- Brown desert soils
- Country border
- Region border
- District border

Soil organic carbon content

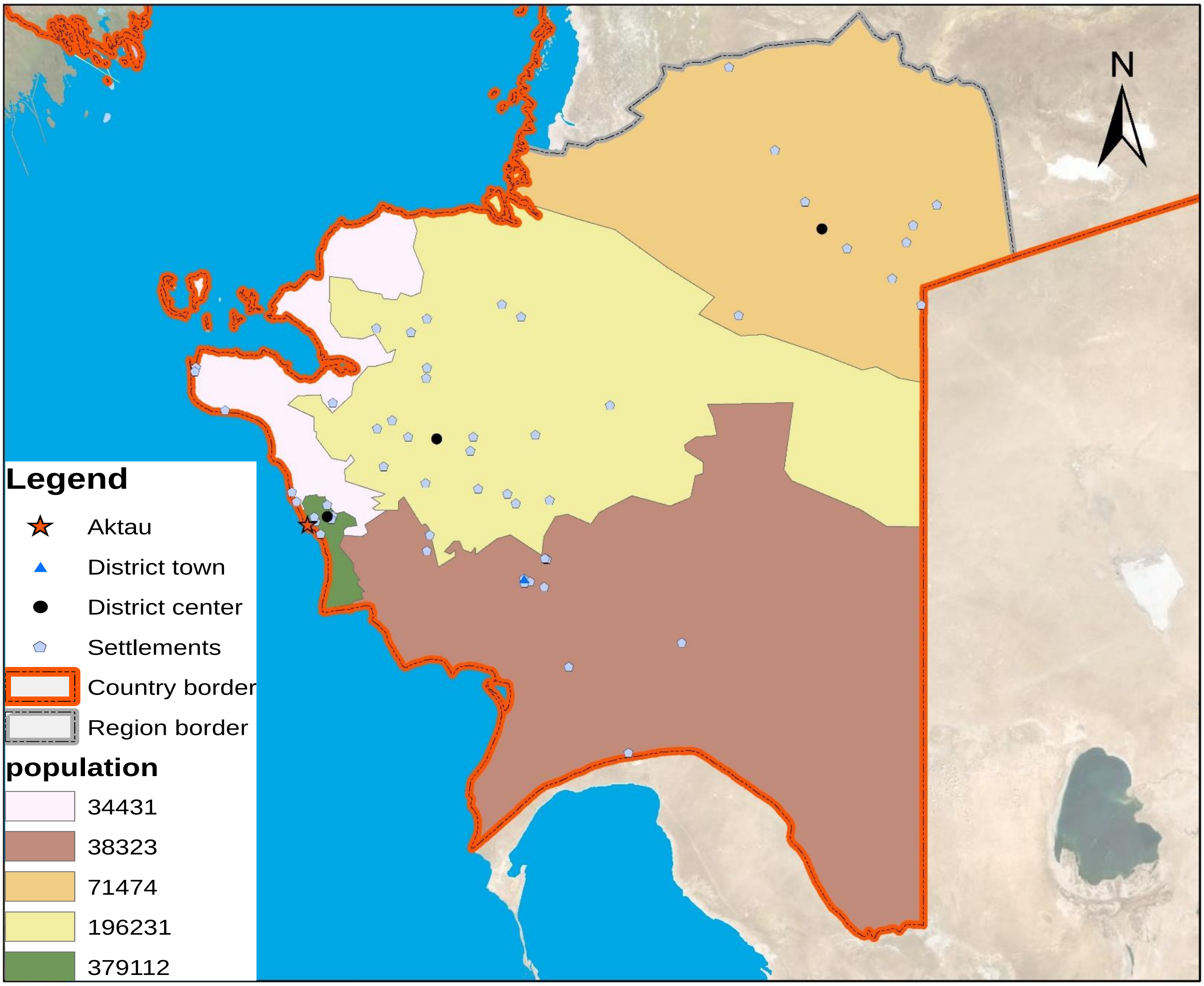


Source: OpenLandMap.org (Hengl and Wheeler 2018).

Soil organic carbon is a measureable component of soil organic matter. Organic matter makes up just 2–10% of most soil's mass and has an important role in the physical, chemical and biological function of agricultural soils.
Organic matter contributes to nutrient retention and turnover, soil structure, moisture retention and availability, degradation of pollutants, and carbon sequestration.

OpenLandMap.org is a data portal to the world's environmental data representing land mask (land cover, vegetation, soil, climate, terrain data and similar). OpenLandMap.org is the web-mapping component of the OpenGeoHub GIS for land data (Hengl 2018).

District wise population



District	total	men	women
Aktau city	204 551	97 954	106 597
Zhanaozen city	156 309	77 961	78 348
Beineu district	71 474	36 247	35 227
Karakiya district	38 323	19 465	18 858
Mangistau district	39 922	20 425	19 497
Munaily district	174 561	88 980	85 581
Tupkaragan district	34 431	17 697	16 734
Total	719 571	358 729	360 842

As of 2021, the estimated population of Mangystau region stands at approximately 719,571. Within this population, around 287,713 people reside in urban areas, while 431,858 inhabit villages.

Compared to other regions of Kazakhstan, Mangystau region is characterized by a relatively lower population, reflecting its more sparsely populated nature.

Source: Statkz.gov 2021

Transportation Infrastructures

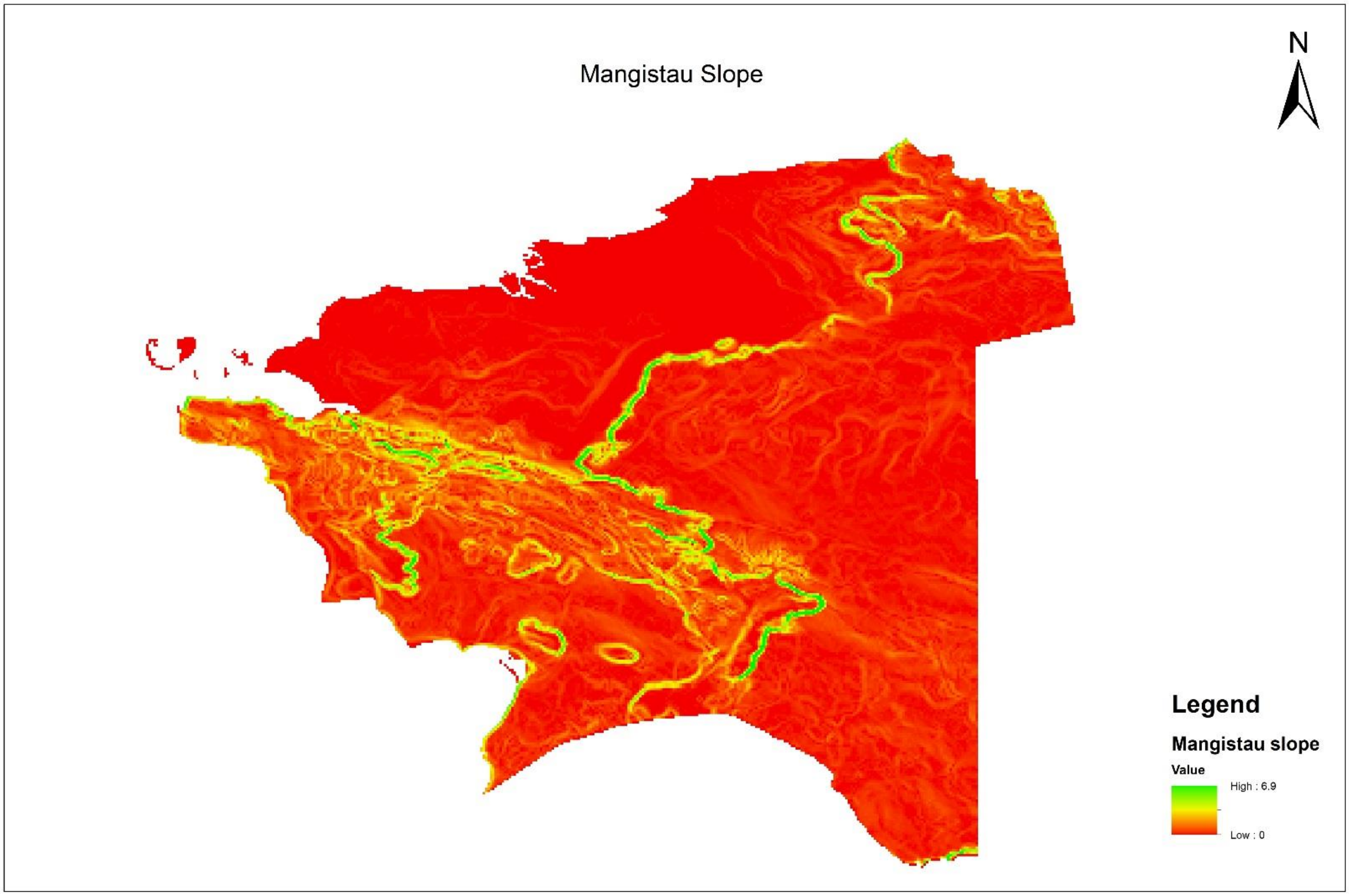
Legend

Source: THE NATIONAL ATLAS OF THE REPUBLIC OF KAZAKHSTAN, 2010 (https://ingeo.kz/?p=3643&lang=en)

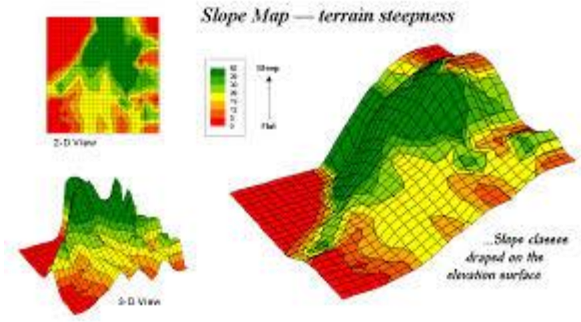
- Railways
- Field roads
- Residential roads
- Main roads
- Country border
- Region border
- District border

The transportation infrastructure in Mangystau region has been thoughtfully designed to promote efficient connectivity among its residents. The road and railway networks have been strategically laid out to ensure seamless and convenient travel across different areas. This well-structured infrastructure not only enhances mobility but also significantly supports regional economic growth by facilitating the movement of goods and encouraging trade activities. It plays a pivotal role in connecting people, providing access to essential services, employment opportunities, and cultural interactions, ultimately elevating the overall quality of life within the region.

Slope map

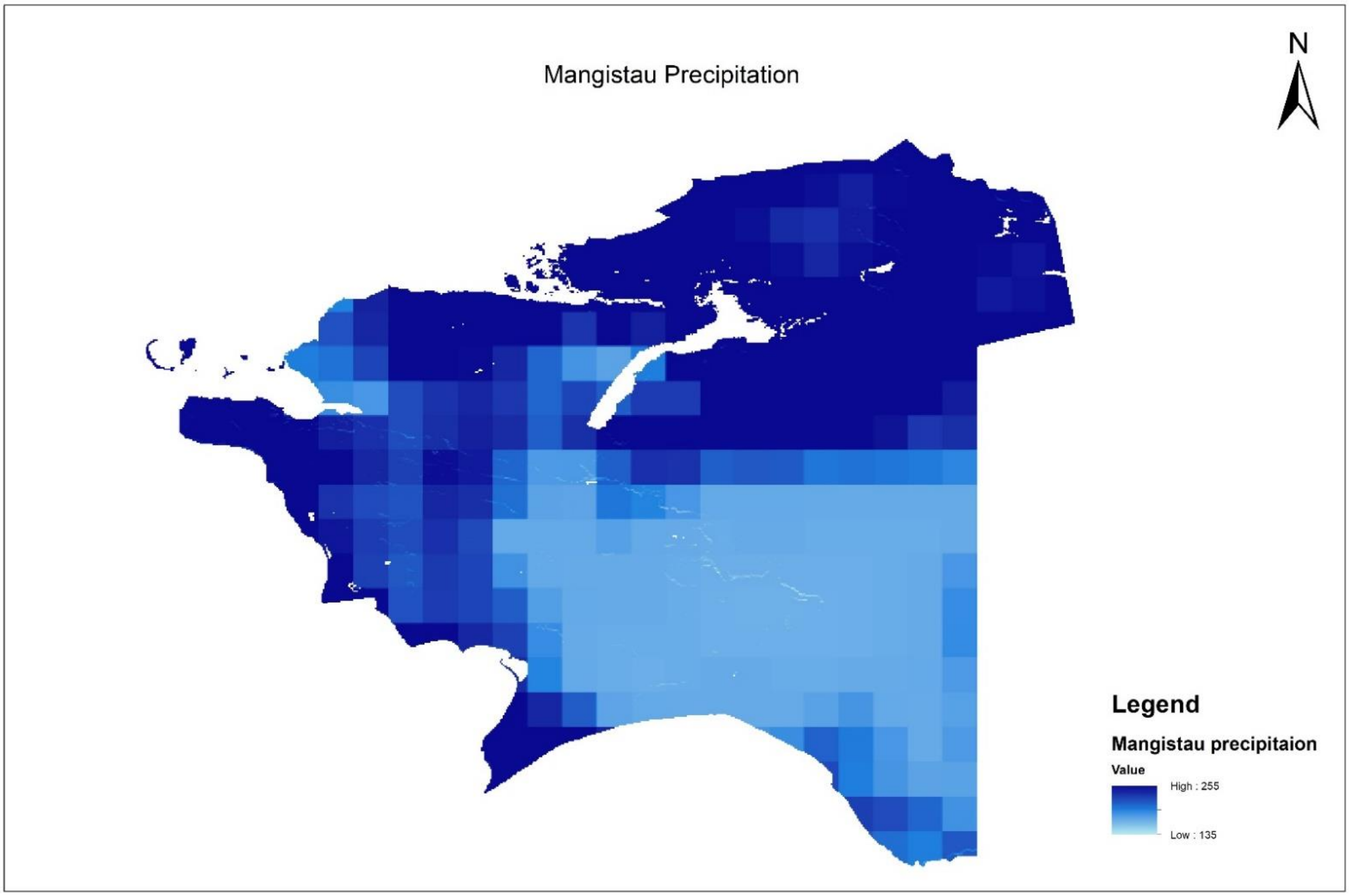


This map was generated using DEM (Digital Elevation Model) data and subsequently colorized to depict the varying slopes within the Mangystau region. These images provide a three-dimensional view that vividly illustrates the steepness and distinctive topographical characteristics of the terrain in the area



The colorized slope representation serves as a versatile tool, effectively conveying terrain steepness across various map scales within the Mangystau region. Its adaptability lends itself well to integration into a wide array of applications and maps, enriching the overall comprehension of the region's topography. Whether applied for local or regional assessments, land use planning, environmental investigations, or recreational purposes, this layer offers valuable insights into the rugged or gentle nature of the terrain. It aids in informed decision-making and fosters a deeper understanding of the geographical characteristics found in the area. Its visual appeal and clarity render it a valuable asset for geographic information systems (GIS) and mapping applications.

Precipitation



We have used the developed tool in Climate Engine platform and through scripting we analyzed Climate Hazards Group Infra Red Precipitation with Station data (CHIRPS) to map annual precipitation in selected study area for 2020. Data is provided for each 0.050 grid sizes and produced as maps.

Data comes directly from the Climate Hazards Center

Historical period: 1988 – 2018

Source: https://chc.ucsb.edu/data/chirps

CHIRPS is a 30+ year quasi-global rainfall dataset. Spanning 50°S-50°N (and all longitudes), starting in 1981 to near-present, CHIRPS incorporates 0.05° resolution satellite imagery with in-situ station data to create gridded rainfall time series for trend analysis and seasonal drought monitoring.

Dataset Availability

1981-01-01T00:00:00 - Present

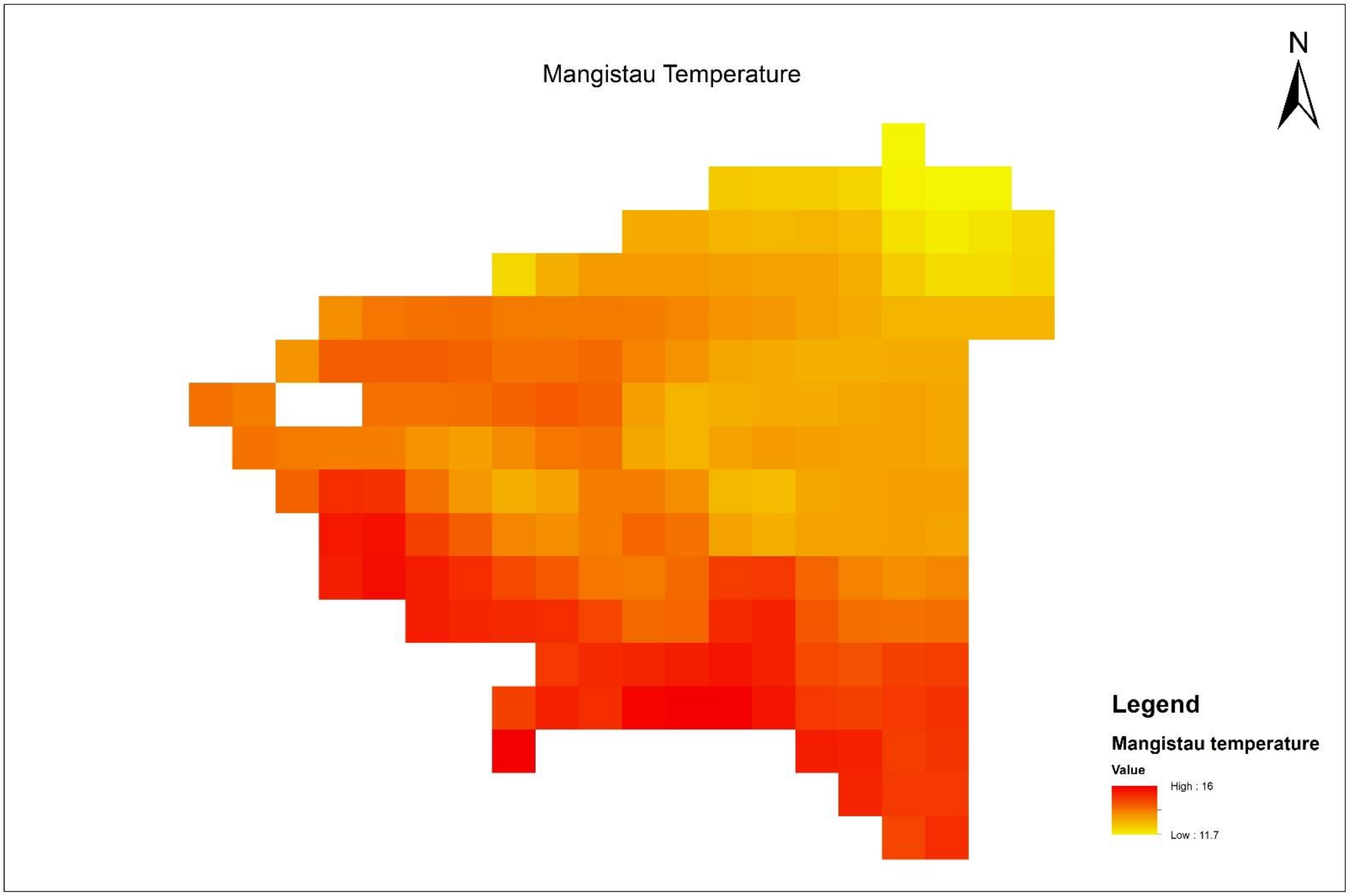
Dataset Provider

UCSB/CHG

Earth Engine Snippet

Climate Engine

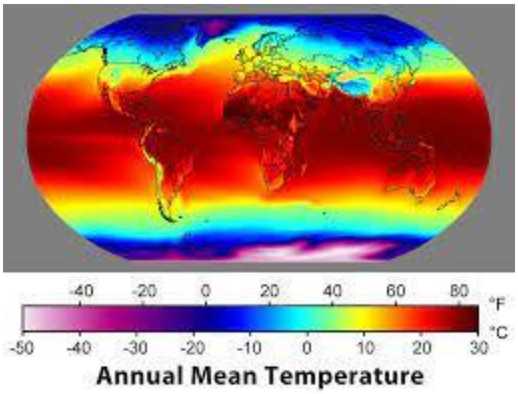
Temperature



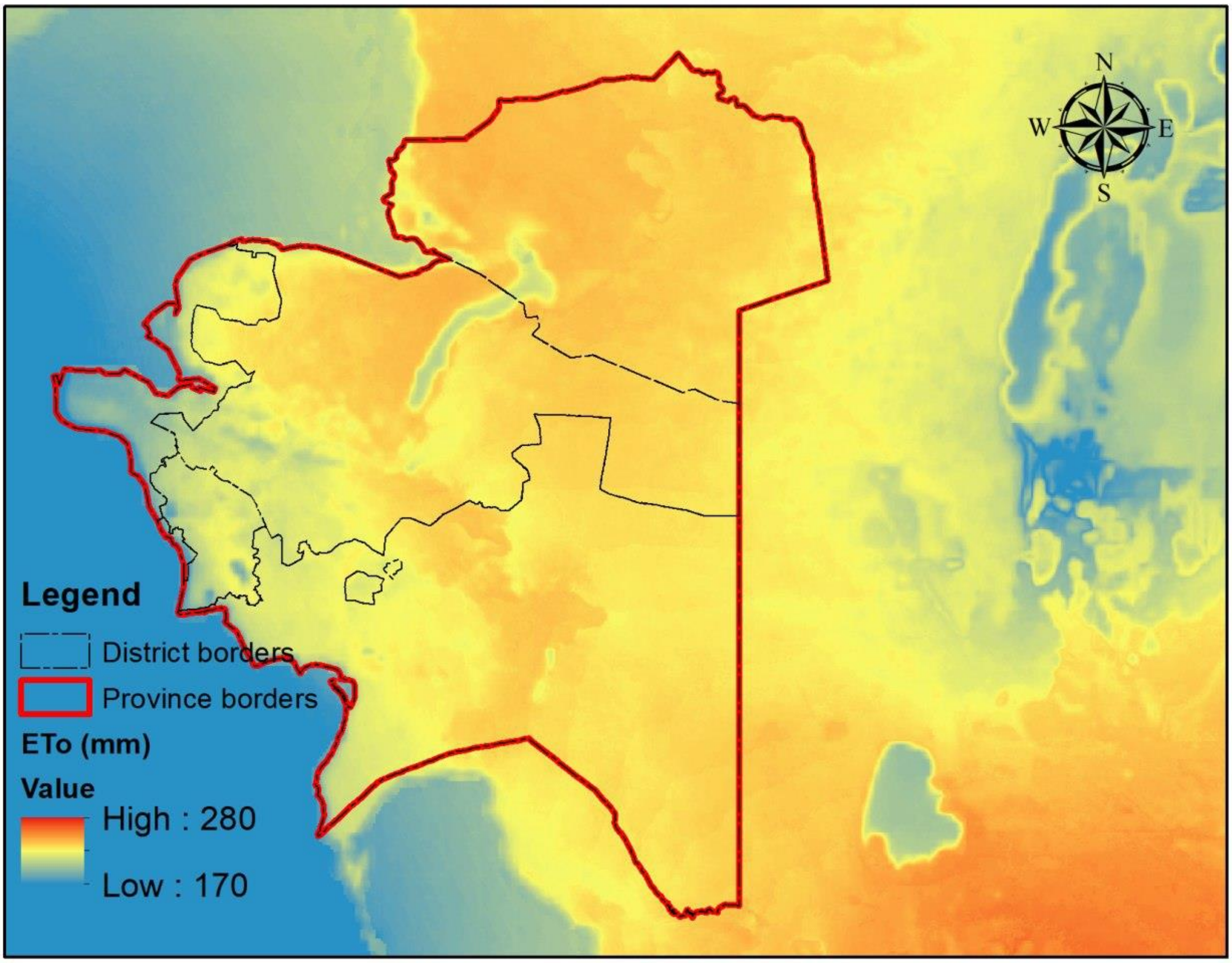
We effectively harnessed our developed tool within the Climate Engine platform to conduct a comprehensive analysis. Through scripting, we delved into the NCEP Climate Forecast System Reanalysis dataset, meticulously mapping annual temperature variations for the year 2020. Our analysis encompassed a carefully chosen study area and provided high-resolution data, with details available at each 0.050 grid size. The outcome was the creation of temperature maps, offering extensive insights into temperature patterns.

This entire process underscores the immense potential of merging cutting-edge tools, scripting capabilities, and reliable data sources, facilitating a deeper comprehension of climate dynamics within the specified area of interest.

Source: https://chc.ucsb.edu/data/chirps



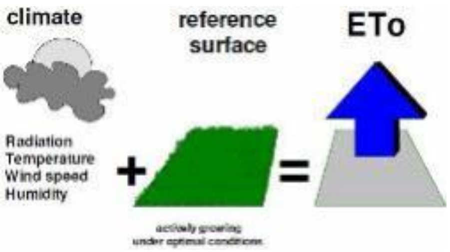
Reference Evapotranspiration in May



Source: TerraClimate (Abatzoglou et al. 2018).

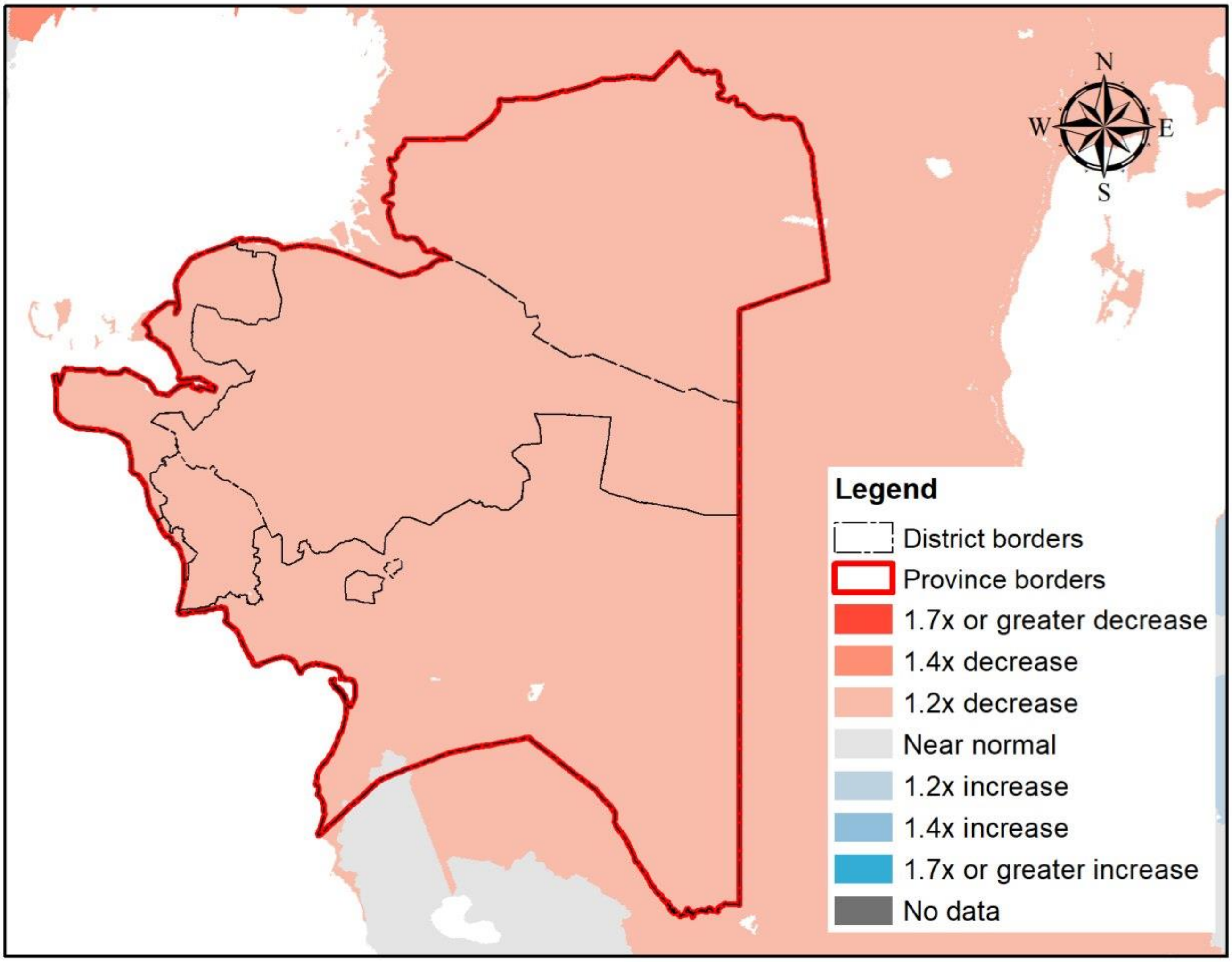
Reference evapotranspiration (ETo) is the evapotranspiration rate from a clearly defined reference surface. The concept was introduced to allow the estimation of the evaporative demand of the atmosphere independently of crop type, crop development or management practices. ETo corresponds to the evapotranspiration from a hypothetical extensive well-watered field covered with 12 cm height green grass having an albedo of 0.23 under the given down-welling short-wave radiation.

TerraClimate is a dataset of monthly climate and climatic water balance for global terrestrial surfaces. It uses climatically aided interpolation, combining high-spatial resolution climatological normals from the WorldClim dataset, with coarser spatial resolution, but time-varying data from CRU Ts4.0 and the Japanese 55-year Reanalysis (JRA55) (Abatzoglou et al. 2018).



Water supply

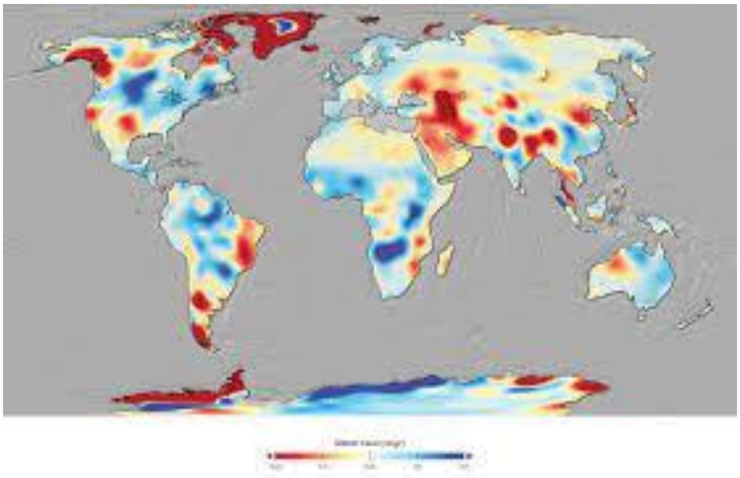
Water supply in 2040 (Change from baseline, Business as usual)



Source: WRI Aqueduct, 2015

WATER SUPPLY

Total blue water (renewable surface water) was our indicator of water supply. Projected change in total blue water is equal to the 21-year mean around the target year divided by the baseline period of 1950–2010.



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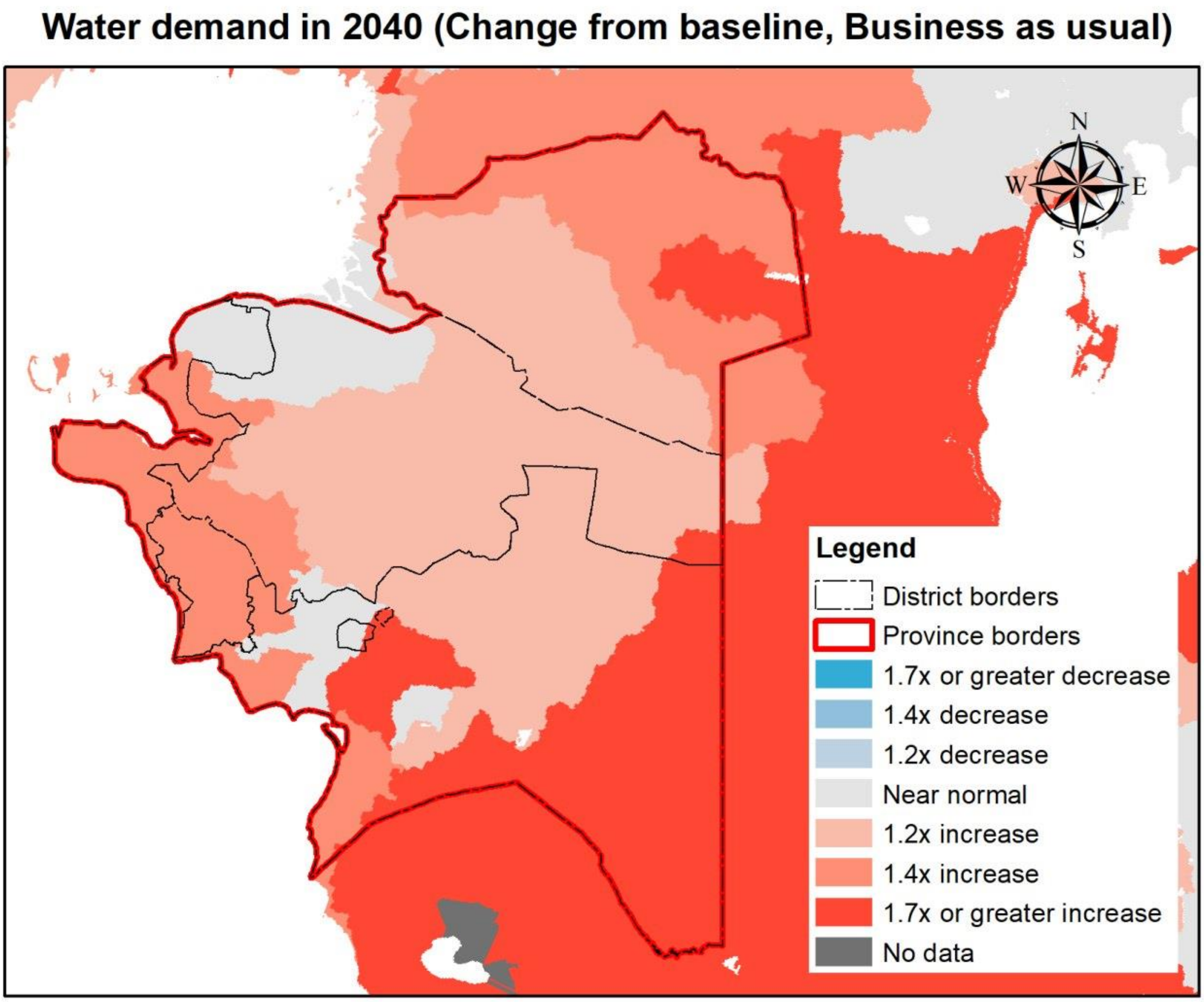
Water demand



Source: WRI Aqueduct, 2015

Water demand was measured as water withdrawals. Projected change in water withdrawals is equal to the summarized withdrawals for the target year, divided by the baseline year, 2010. Since irrigation consumptive use varies based on climate, we generated unique estimates of consumptive and non-consumptive agricultural withdrawal for each year. Estimates for consumptive and non-consumptive agricultural withdrawal for each ensemble member, scenario, and target year are the mean of the 21-year window around the target year.

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International Water Management Institute
Headquarters and South Asia Regional Office
127 Sunil Mawatha, Pelawatta, Battaramulla, Sri Lanka
Mailing address: P. O. Box 2075, Colombo, Sri Lanka
Tel: +94 11 2880000, 2784080
Fax: +94 11 2786854
Email: iwmi@cgiar.org

Central Asia Office
Office 118, Building 6, Osiyo Street,
Tashkent 100000, Uzbekistan
Tel: +998 71 2370445
Fax: +998 71 2370317
Email: iwmi-ca@cgiar.org

Website: www.iwmi.org

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International Water
Management Institute

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