



Research Article

# Representation of medieval climate fluctuations in Central Asia in the toponymic system: Historical and geographical data

Kulyash Kaimuldinova<sup>1</sup>, Shakhislam Laiskhanov<sup>1</sup>, Duman Aliaskarov<sup>1</sup>, Rakhat Tobajanov<sup>1</sup>, Zhulduz Nizamatdinova<sup>2</sup>

<sup>1</sup> Abai Kazakh National Pedagogical University, Almaty, Kazakhstan

<sup>2</sup> Yessenov University, Aktau, Kazakhstan

Corresponding author: Shakhislam Laiskhanov ([laiskhanov@gmail.com](mailto:laiskhanov@gmail.com))

## Abstract

This article considers the nature of climate changes in the Middle Ages of Central Asia and the influence of these changes on the toponymy in the region. The aim of the study is to analyze the manifestation of climate changes in the names of natural objects described in historical data of Central Asia and to study whether the semantic load of toponyms corresponds to the current geographical reality. The spatial identification of toponyms found in medieval historical sources, their etymological and semantic analysis, determination of the correspondence between toponyms and the present geographical nature of objects are carried out in accordance with the aim of the research. Climate changes will lead to changes in soil, vegetation and fauna. The presence of information describing the natural conditions in the period of their appearance in toponyms makes it possible to use them as indicators of landscape changes in historical geography. It was found that toponyms reflect climate changes in Central Asia, and thus they can be used as a source of information in the reconstruction of landscapes of past periods as a result of the research. It was found that the meaning of historical names preserved in the region from the period called “medieval pluvial” or “medieval climate anomaly” (between 900–1300 AD) does not correspond to the nature of the present landscape as a result of climate changes. The research methodology and results can be used in the future on a wider scale for other regions or in historical-geographical studies related to certain time periods.

**Key words:** Middle Ages, historical geography, toponyms of Central Asia, climate changes, medieval pluvial

## 1. Introduction

In the Middle Ages, Central Asia united various linguistic and cultural differences as an intersecting place of nomadic and sedentary culture. The diversity of natural environment is explained not only by the combination of flat and mountainous landscapes but also by the difference in the ratio of heat and moisture, which changes in the latitudinal direction. Formation of the informative load of toponyms is a complex interaction of ecological, cultural and socio-political



Academic editor: Mariyana Nikolova

Received: 08 December 2024

Accepted: 07 January 2025

Published: 06 February 2025

**Citation:** Kaimuldinova K, Laiskhanov S, Aliaskarov D, Tobajanov R, Nizamatdinova Z (2025) Representation of medieval climate fluctuations in Central Asia in the toponymic system: Historical and geographical data. Journal of the Bulgarian Geographical Society 52: 21–36. <https://doi.org/10.3897/jbgs.e143846>

Copyright: © Kulyash Kaimuldinova et al. This is an open access article distributed under terms of the Creative Commons Attribution License (Attribution 4.0 International – CC BY 4.0).

factors. It can be said that the different representation of the environment nature in the geographical names of the peoples of Central Asia from the point of lifestyle and linguistic, cultural and worldview has complicated the toponymic features of the region. Climate change is interpreted not only as a change in physical processes and systems of the earth but also as a cultural and spiritual problem (Dorji 2024). In addition to its current status as a global problem, it is also very important to study the changes in different periods of history. These studies help to learn the spatio-temporal characteristics of the climate, adapt to climate changes based on the “historical memory” of the natural environment and create strategies for the restoration of natural and historical cultural landscapes. From this point of view, toponyms can be used as a landscape indicator or a means of recognizing the history of the natural environment (Donada and Reinoso 2014; Atasoy and Yeginbayeva 2017; Wang et al. 2019; Spampinato et al. 2022)

In Central Asia, the dynamics of climate, which began in the 20th century, “has been changing” the geographical characteristics of natural objects, as a result of which the information stored in ancient toponyms does not correspond to the current geographical reality. In general, the evolution of toponyms reflects the changing landscapes and adaptive strategies of local communities. Therefore, researchers can gain valuable information about how climate change has formed human experience and cultural identity in Central Asia by studying the historical and contemporary meanings of toponyms. This comprehension is very important to preserve the rich cultural heritage embedded in the toponymic landscape of the region, making it a source of information for historical geography. However, landscapes, including climate, have not been sufficiently studied in geographical aspect through the toponymic approach (Atasoy and Yeginbayeva 2017).

As a result of the research, it was found that there is a group of names that reflected climate changes in the Middle Ages, in the rich toponymic heritage of Central Asia. Questions of the research related to this work are given below that help to comprehensively study the informative load of historical toponyms in the region and in close connection with the changes in the natural environment:

1. What were the spatial extent and indicators of climate fluctuations in Central Asia in the Middle Ages?
2. What geographical objects of Central Asia are described in medieval original sources?
3. Does the meaning of the names of toponyms found in medieval sources correspond to the natural conditions of that time and now?

## 2. Data and methods

### 2.1. Literature review

#### 2.1.1. Fluctuations of Central Asian climate in the Middle Ages

Climate change in historical periods of Central Asia has occurred as a result of complex interaction of environmental factors, including tectonic movements, global and regional circulation changes. The uplift of the Tien-Shan mountains and Tibetan plateau significantly changed the climatic conditions in Central

Asia, leading to increased droughts in the region. This uplift during the Miocene led to broader climatic changes that underpinned the ecological conditions observed in the Middle Ages (Qiu and Liu 2018; Song et al. 2022).

The geological and climatic evolution of Central Asia shows that the region changed from a subtropical climate to an arid environment, which was partly influenced by the orography of the surrounding mountain ranges (Kaya et al. 2019). In the Middle Ages, Central Asia experienced significant climatic fluctuations that affected the hydrological structure of the region. Studies have revealed that the effective humidity level in Central Asia is influenced by westerly winds, which played an important role in moisture transport over the region (Hong et al. 2014; Caves et al. 2015). The processes of aridification, which began in early geological periods, continued in the Middle Ages and led to significant ecological and cultural changes. For instance, civilizations such as the Oxus civilization flourished and declined due to climate change, as a result of this agricultural productivity and resource availability have been changed (Luneau 2019).

During the Middle Ages, humidity conditions throughout the Northern Hemisphere, including Central Asia, underwent complex transformations of various nature. It is considered that the period called “Medieval Climate Anomaly” or “Medieval Climatic Optimum” occurred between 900–1300 AD in a scientific environment (Mann 2002).

This period was distinguished by complex climate patterns that differed greatly across geographic regions, as a result of it, it is considered that the time of warming and hydrological change greatly influenced ecosystems, agriculture and human livelihoods. It is observed that some areas experienced an increase in summer precipitation, while others experienced prolonged dry periods (Hong et al. 2014; Jin et al. 2011). For example, the last pluvial period in the Aral and Caspian basins covered approximately VI-XII centuries (Borzenkova and Lemeshko 2006). Cereal pollen with a mixture of tree pollen up to 38% was found in the palynological spectra of the VI-XII centuries found on the northern slopes of the Mangystau mountains and this proves the presence of forest cover in this area during the medieval pluvial period (Varushchenko et al. 1987; Babkin 1998).

Special studies have proved that in the Middle Ages of the flat part of Central Asia, which is dominated by deserts and semi-deserts at present, it is explained that the driving force of these changes was the North Atlantic oscillations (Feng et al. 2022).

The impact of the medieval climate anomaly on the socio-economic situation in Central Asia was particularly evident in terms of agricultural productivity and social stability. As a result of the recovery of tree rings, which prove a warm and constant humid climate in the 13th century, it was concluded that favorable climatic conditions may have contributed to the expansion and success of the Mongol Empire (Pederson et al. 2014). This correlation between climate and socio-political events highlights the importance of understanding historical climate patterns in the context of human history. In addition, the climatic conditions of the Medieval Climatic Optimum affected the biodiversity of plants in Central Asia. Studies conducted on the northern slopes of the Tien-Shan mountains have revealed that the medieval period was characterized by significant climatic changes that affected local ecosystems (Zhang et al. 2009).

Climate changes during this period did not occur as isolated events; they were part of a global pattern of environmental change that included large fluctuations in temperature and changes in vegetation dynamics. As studies have revealed, these climate changes in Central Asia immediately affected the vegetation, the changes in the distribution of species corresponded to the changing nature of the climate (Yin et al. 2019; Baldermann et al. 2021). The cumulative effect of these changes contributed to human society's resilience and adaptation to environmental stressors, reflecting the complex relationship between climate and civilization in Central Asia during the Middle Ages. These factors did not only affect the natural environment but also greatly contributed to the cultural and social development of the region.

### 2.1.2. Description of geographical objects of Central Asia in original medieval sources

Place names in Central Asia have great cultural significance, they reflect the collective memory of communities and the identity of ethnic groups. For instance, the traditional ecological knowledge of the Kazakh people is deeply rooted in its toponymic system and reflects its comprehension of climatic conditions and environmental changes (Kaimuldinova et al. 2023). This knowledge is very important for sustainability as communities can introduce modern practices to cope with the challenges of climate change. The change of toponyms in response to climate change is evidence of the stability and adaptation of the population in adverse environmental conditions.

The socio-political aspects of climate change in Central Asia also affect toponymic changes in addition to agricultural and environmental consequences. As water scarcity has become an urgent issue, conflicts over water resources bring to the fore new political realities or territorial requirements (Sabyrbekov et al. 2023), which in turn may lead to the changes of toponyms. The historical context of these names can bring to hidden tensions in the region, revealing how climate change exacerbates socio-economic problems and affects cultural phenomena.

The historical analysis of place names can also provide valuable insight into the long-term consequences of climate change for Central Asian landscapes. For example, the study of ancient toponyms can reveal how past climatic conditions influenced settlement and land use patterns (Jacobson et al. 2022). Researchers can reconstruct historical landscapes and understand how communities interacted with their environment over time by studying the linguistic roots and meanings of ancient toponyms. This historical perspective is very important for comprehension of the current challenges posed by climate change and developing effective adaptation strategies.

The expression of climate change in place names is not limited to an agricultural or ecological context; it also includes cultural and social aspects. Toponyms often reflect the cultural significance of natural objects, which may change as these objects change due to climate change. In Central Asia, the ongoing loss of glaciers or lake level dynamics associated with climate change (Zhang et al. 2021) may lead to the abandonment of traditional names to be replaced by new names that reflect the changed landscapes (Laiskhanov et al. 2023).

This process reveals the interaction between environmental change and cultural identity because communities grapple with the loss of familiar landscapes and the need to adapt to a new reality.

It should be noted that the manifestation of climate change in toponyms in Central Asia is a complex interaction of environmental, cultural and socio-political factors. As climate change continues to affect the region, the evolution of place names reflects the changing landscapes and adaptation strategies of local communities. Considering the historical and contemporary significance of toponyms, researchers can gain valuable information about how climate change has formed human experience and cultural identity in Central Asia. This understanding is very important for developing effective policies and strategies that address the challenges posed by climate change while preserving the rich cultural heritage embedded in the region's toponymic landscape. Also, toponyms are the historical memory of the geographical environment, and natural and cultural landscapes can be restored with their help.

## 2.2. Methods

Research methodology includes descriptive, analytical, comparative and synthetic methods. In this study, an overview of research on climate change in Central Asia was provided and for the first time in the example of Central Asia, the author's methodology was used to study the changes in the natural environment under the influence of climate fluctuations through the geographical description of objects and the meaning of toponyms.

In the first stage of the research, the nature of climate changes in the Middle Ages and how these changes affected toponyms were considered by reviewing the thematic literature. Geographical thematic literature, historical sources, researches of modern authors were used to study the description of medieval climate fluctuations in Central Asia in toponyms.

In the second stage, the meaning of the names of geographical objects described in specific sources was analyzed. As original sources, the notes and maps of Central Asia by medieval travellers and scholars were used. Lexical and semantic analyzes were carried out to determine the informative load of historical names.

In the third stage, the representation of climate changes in the Middle Ages in historical toponyms is determined on the example of real geographical objects, and the perspective of the use of toponyms in landscape reconstruction is proposed. Geographical, historical, toponymic information from various sources was analyzed from synchronic and diachronic point of view using the comparative-geographical method.

## 3. Results

When studying the climatic conditions of the region, researchers rely on data from meteorological observations, materials from remote sensing of the earth or the results of field studies in which meteorological characteristics are measured. Although these data are accurate and processed quickly, they cannot reflect multi-century climate conditions and changes. According to the opinion of a number of scientists (Savvinova et al. 2016; Dorji 2024), the use of geo-

graphic names as a source of information in such studies helps to solve the problem. Residents who have lived in one place for a long time gave names to geographical objects based on the seasonal features of the natural environment, and explorer scientists during their travels gave names to geographical objects based on the natural and climatic features of the places. Because, nature, climate, geographical location, and historical conditions are the conditions that influence the formation of toponyms (Ayubov 2021).

This historically established experience gave us the possibility to determine the climate fluctuations of Central Asia during the X-XIII centuries and use toponyms as an informational basis in the research.

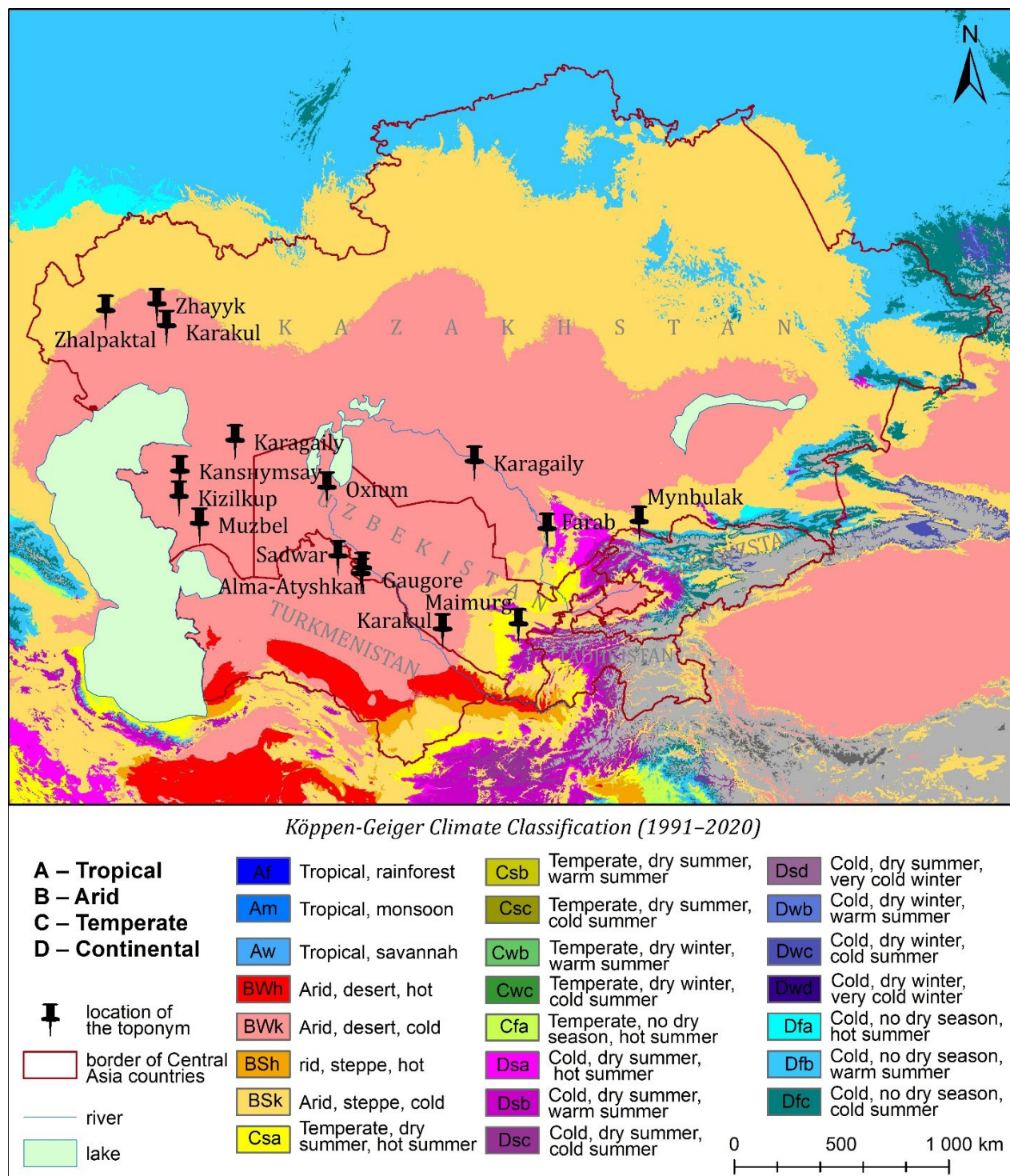
The information provided by medieval toponyms, which chosen by us as an example, does not correspond to present climatic conditions. We used the Köppen-Geiger climate classification to show it. The Köppen-Geiger climate classification system consists of five main groups based on seasonal precipitation and temperature regimes: A (tropical), B (arid), C (temperate), D (continental) and E (polar) (Beck et al. 2023). Their four groups are typical for Central Asia. Each group is divided into several types according to the type of seasonal precipitation and heat level (Fig. 1).

According to the Köppen-Geiger climate classification, the climatic zones of Central Asia are presented according to climatological data for 1991–2020 and the distribution of medieval toponyms in these climatic zones is shown. The map was compiled in the program ArcGIS 10.5 using Köppen-Geiger high spatial resolution GeoTIFF images and classification legend (Beck et al. 2023) and historical and reference data on the geographic location of toponyms. A number of types of toponyms found in different regions of Central Asia provide information about the differences in climate which are compared to the present (Table 1).

Gulyamov (1957) writes in his work that some changes took place in Khorezm between the writing of the works of Ibn-Ruste and Istakhri and the writings of Makdisi. These changes meant, firstly, that the channel of the Vadaq-Buve canal, connected to the waters of the Amudarya, became so large that the territory of Gurganj (Urgench) was in danger of being flooded. In general, in the 9th–13th centuries, due to the abundance of water in the Amudarya, hydraulic constructions were intensively carried out in Khorezm. The waters of Amudarya reached the Ustirt plateau in the west, forming large bodies of water and still flowing into the Aral sea.

There are works that connect “Oxy lake” (Oxia palus) with the Aral Sea or consider it as a separate lake. Arab geographers: Ibn Khordadbeq and Ibn Rust wrote in their writings a giant lake flowing into the Amu Darya and Syr Darya—Lake Kurder (Bukhaira). The lake they described corresponds to the characteristics of the modern Aral Sea (Ashirbekov and Zonn 2003). The dictionary of Greek and Roman geography (William 1854) indicates that this lake is the Aral Sea. It is likely to be a giant swamp formed in the lower reaches of Amudarya, apart from the Aral Sea (Barthold 1965). In any case, it is clear that this lake was formed in the period of abundant water of Amudarya.

Barthold (1965) wrote that “Sadvar” coincides with the current name of the locality. As a result of archaeological research, building elements of the IX-XII centuries were found. This city was a trade and craft center along the caravan routes of Khorezm. The city may have been destroyed by floods before the Mongol-Tatar conquest of Central Asia (Itina 1991). “Topyrk-kala” (which



**Figure 1.** Distribution of medieval toponyms by climatic zones.

means “fortress covered with earth”) in the right bank of Amudarya, like other cities, was well developed in the 10th century, but in the 11th century it disappeared due to a long period of flooding.

The ancient city of “Alma-Atyshkan (Savkan)” was among the prosperous cities, 18 km to the east of Khiva in the territory of Kattabag settlement. At present, this town is located at the end of the Savkan canal, which has been

**Table 1.** Toponyms describing climate change in the Middle Ages (Barthold 1897; Barthold 1965; Masson 1966; Kushimova 2010; Maryksin 2013; Bissembaev and Akhatov 2016; Ayubov 2017; Kamoliddin 2019; Sandiboev and Shirinov 2021).

Name and location of the toponym	Origin	Class of toponym	The type of climate indicated by the toponym (according to Strakhanov 1960)
“Jalpaktal” town—on the border of Kaztalov and Zhanakala districts of West Kazakhstan region, 5 km to the north-west from Janazhol village, near Aktash wintering	The name of Jalpaktal settlement comes from the Turkic (Kazakh) words, where “jalpak” means flat or wide, and “tal” means meadow or pine	Oikonym	Humid
“Maimurg”—bordered Samarkand in the northeast in the early Middle Ages and united the lands of Urgut, Tailek and Samarkand districts	“Main” means a settlement and “murg” means grass, meadow (a settlement rich in meadows) from the Sogdian language	Oikonym	Humid
“Gaugore”—a historical canal in the Khorezm region of Uzbekistan	Literally means “food of cows” from the Persian-Tajik language	Hydronym	Arid
“Muzbel” ridge (404 m)—a ridge of Mughalzhur mountain which is located in the South-Western part of Usturt, Mangystau district of Kazakhstan	It means “ice hill” in the Kazakh language	Oronym	Nival
“Oxy lake” (Oxia palus) is located in the lower reaches of the Oks (present Amu Darya) river (in Uzbekistan)	“Oxia” comes from the Greek for “sharp” or “sour” and “palus” comes from the Latin for “swamp” or “lake”.	Gelonym	Arid
“Sadvar”—in the Lebap region of Turkmenistan	It means “port” or “harbour” in the Turkmen language	Agronym	Arid
“Alma-Atyshkan”—the site of an ancient city located 18 km to the east of Khiva, Uzbekistan	It means “apple-shot” from the Turkic language	Oikonym	Arid
“Farab-Farabr” (Farabr)—an ancient city/settlement found in several regions of Central Asia	It means “a lot of water, a lot of water sources” translated from the Arabic language	Oikonym	Arid
“Kara kol” (Kara kul)—near the city of Baikand (East Turkestan) and West Kazakhstan (Atyrau region)	It comes from the Turkish word and means “black lake”	Limnonym	Arid
“Zhayik”—a large river in the west of Kazakhstan, a continuation of the Ural river	It means “wide-spread flowing water” from the Turkish word “Yaik”	Hydronym	Arid
“Karagaily”—the name of a place and well in Mangystau and Kyzylorda regions of Kazakhstan	Pine refers to a place or region with a large number of trees in relation to landscape features.	Oikonym	Humid
“Kanshymysai”—a dry riverbed in Mangystau district, Mangystau region of Kazakhstan	“Kan” means “spring”, “channel”, “source”, “Shym” means “surface layer of the land covered with perennial grass”, “sai” means “a low-lying place”	Hydronym	Humid
“Kanshymturan”—a relief hilly area located on the plateau	The meaning of the name is: “turf reservoir filled with spring water”	Oronym	Humid
“Kyzylkup”—a dry gorge located in the Mangystau region of Kazakhstan and Balkan region of Turkmenistan	Persian “kup” is a container for pouring water. Kyzylkup means “a stony bottom at the bottom of the red-lined square, a place where water collects”	Oronym	Humid
“Mynbulak”—a place located 400 li (200 km) to the west of Shu, and 140–150 li (70-75 km) to the east of Talas	Mynbulak—a place where a thousand springs (a very large number of springs) meet	Oronym	Humid



dried up (Gulyamov 1957). The name of the locality where the city is located is “KattaBag” means “big garden”.

In “Maimurg”, unlike neighboring areas, irrigated agriculture was well developed. There was a dam (Varaksa) that supplied water to a large area, including Samarkand and its surroundings. Along with agriculture, horticulture and animal husbandry are well developed in the mountainous and hillside areas of the valley. It is recorded that jewelry, dancers, wild animals—lions were brought from Maimurg to the residence of Tang rulers (Barthold 1965; Ayubov 2017). He wrote that there are 6 rustags (an ancient city surrounded by mountains and greenery, which is a beautiful oasis of nature) to the south of Samarkand, and Maimurg is the most densely populated among them. This probably means that Maimurg’s nature was favorable. And the water of Zarevshan was not enough for Abgar rustag. Crops were grown here with rainwater. In the years when the harvest was plentiful, Abgar harvested enough to feed the entire Sogdian population (Kamaliddinov 1966). Here, the toponym “Sogd” (an ancient historical city-state in modern Uzbekistan) means “the place where all rainwater flows” (Ayubov 2021).

According to Masson (1966), in the Middle Ages in Central Asia, the toponym “Farab” was often found in cities and settlements near rivers and canals. There is data that such names were in the name of a city along the Syrdarya river in the Otyrar district of the Turkestan region of Kazakhstan, the name of a village in the Kitab district of the Kashkadarya region, the name of a district in the Chardzhou region of Turkmenistan and the name of a city located opposite to the Amul river on the right bank of the Amudarya.

One of the names indicating the abundance of water in the local area is “Myn bulak”. Hsuan Tsang referred to this place as “1000 springs” and said that it was located 400 li (200 km) to the west of Shu and 140–150 li (70–75 km) to the east of Talas and writes that there were many lakes, ponds, tall and dense trees in this area (Barthold 1897).

According to Narshahi, there was a large lake near Baykand where the excess water of the Sogd river flowed. The Turks who lived here called this lake “Karakol” or “Dingiz”. It is said that its area is stretched up to 20 farsakhs (Kamoliddin 2019). The city of Baikand is located in East Turkestan, according to one source, it is located along the road from Bukhara to Khorasan (Kamaliddinov 1996). Barthold (1965) indicates that this water body is a “pond” near Peykend and near Ferebr, where the Zeravshan flows. Geographers of the 10th century did not provide any information about it. In the last edition of Narshahi’s work (XII–XIII centuries), the water body is mentioned in the Persian (Bargin-i Ferah “a large water reservoir”) language and (“Karakol”) is mentioned in the Turkish language and there were more birds and fish here than anywhere else in Khorasan.

According to the data of Remezov (1701), Karakol lake was also in the region of West Kazakhstan. In the “Big Book of Drawing” compiled in 1627 (Ibn Hawqal and Abu-l-Kasim 1957), the data about the Oyil river, the fact that this river sinks into the ground before reaching Zhaiyk and that there are eight lakes called Karakol at the mouth of this river, are very valuable not only for toponymy but also for historical geography.

After the Mongol invasion, several cities emerged in the western part of Kazakhstan. This may be directly related to the natural state, which is the main factor influencing population settlement. Some of the toponyms here may describe the natural conditions at that time. One of them is “Jalpaktal” settlement.

The name of Jalpaktal settlement comes from Turkic words, where “jalpak” means flat or wide, and “tal” means meadow or “pine”. This name may indicate that the area where this settlement located was a pine forest or an area of trees. In addition, the toponym “Karagaily” is spread in the desert zone as a phytonym that does not correspond to its present feature. Pine forests are mainly distributed in the Altai and Saur mountains with good rainfall in the east of Kazakhstan, in the valley of the Irtys river, in the low mountain granite massifs of Saryarka in Central Kazakhstan and the Torgai mountain range in the North (National Encyclopedia 1998). However, these toponyms are common in desert regions characterized by flat topography: two names in Mangystau region, one name in Kyzylorda region. There is a wintering and well called Karagaily in the Beineu district of the Mangystau region (Kushimova 2010).

In addition, Zhaiyk river stands out among toponyms in Western Kazakhstan. In the writings of Ahmed Ibn-Fadlan, who travelled along the Volga in 908–932, there is an evidence that “Jaikh” (present Zhayik) was called “the largest and most powerful river we have seen”. Based on his observations of the Oghuz people’s lifestyle in this region, this period corresponds to winter (Krachkovsky 1939). As a result, the waters of the Urals were abundant even during the winter months (perhaps even more so in the spring). In general, there are many toponyms that define the high humidity in the desert of Western Kazakhstan. They are: “Kanshymsai”, “Kanshymturan”, “Kansu” (it is met a lot), “Kankum”, “Kankudyk”, “Kandybas”, “Kankystau”, “Kanai”, “Kangga”, “Kangababa”, etc. The word “kan” (blood) in these toponyms is a geographical term used in the sense of “water”, “river” (Kushimova 2010). In addition, there are oronyms derived from the root “kup” (derived from the Persian word for water vessel, watery). As an example of this, “Kyzylkup” and “Zhetikup” gorges can be mentioned (Span and Duysenbaeva 2006). Now these geographical places have turned into dry, barren fields without water. Kyzylkup gorge is also found in Turkmenistan.

“Gaukhore”—the name appears for the first time in the works of Istakhri. This name is interpreted as a Persian-Tajik name and literally means “food of cows”. Gulyamov (1957) claims that this name has a second meaning: this word is mentioned as “Gauvore” in the works of Arab scholars, so it reminds of the Persian word “hur”. And the word “gau” may mean “stream” associated with old canals. In any case, this name seems to indicate the thick vegetation of the area.

#### 4. Discussion

In general, the urban civilization of medieval Khorezm of the X-XV centuries in the territory of the Amu Darya oasis and the Aral region passed through various stages of development (Kdyrniyazov 2013). Historical facts indicate that natural factors also influenced the development of civilizations along the Syr Darya and Amu Darya rivers. This can be analyzed in connection with toponyms such as Sadvar, Alma-Atishkan (Savkan), Topryk-kala, Maimurg, Sogd, and Farab. These cities and settlements flourished and developed during this period (Barthold 1965; Ayubov 2017; Kamoliddin 2019; Sandiboev and Shirinov 2021). The migration of people from cities (Sadvar, Topryk-kala,) in Central Asia has been related to climate change (Itina 1991). The Uzbek scientist Ayubov (2021) revealed that no matter what the situation was, the migration process of Cen-

tral Asian people from their primary place is determined by the geographical location of the land and favorable climate.

According to the data of Ibn Hawqal and Abu-I-Kasim (1957), in the 10th century, opposite the city of Akhsiket, there were only meadows and pastures on the left bank of Syrdarya, and after one day's journey, the sands were stretched. Babur (1992) describes that the right bank of Akhsikent in Ferghana was a field, the left bank was a forest, on the right bank antelopes, and on the left side deers, marals, pheasants and rabbits were caught. These data suggest that the oases along the Syrdarya river occupy a very large area, and even one side may even be connected with forested steppe.

If the movement of Mongol troops to the south of Kazakhstan seriously damaged the tradition of urban planning with a centuries-old history of development, for West Kazakhstan, paradoxically, the period of the 13th–14th centuries was the formation and development period of cities and settlements that occurred as a result of the administrative and resettlement policy of Genghis Khan's descendants (Bisseмбаев and Akhatov 2016). This may be directly related to the natural state, which is the main factor influencing population settlement.

The changes in the above-mentioned landscape and the formation of new toponyms are undoubtedly primarily related to temperature. As a result of the study of climate change along the ancient Silk Road over the past two millennia, Hao et al. (2020) suggest that “a warm climate” developed from the late 7th to the early 11th century and from the mid-12th to the mid-13th century due to rising temperatures. However, the Soviet scientist, the founder of the theory of “climate moistening for many centuries” Shnitnikov (1957) wrote that the climate and general humidity of the Northern Hemisphere continents changed cyclically between 1500–2100 years, the cold-humid era lasted 300–500 years, the warm-dry era lasted 600–800 years, and then the transitional period lasted 700–800 years. According to his theory, the XIV-XIX period was a wet-cold period and before that, there was an interval period of 700–800 years (Shnitnikov 1957).

This caused significant changes in the vegetation cover, which is the most “sensitive” component of the landscape. According to Atasoy and Yeginbayeva (2017), phytotoponyms provide information about the past of certain types of plants and make it possible to create a picture of historical landscapes. Analysis of their historical distribution gives possibility to determine the reasons for the formation of economic types due to human influence and climate change (Spampinato et al. 2022).

In our previous researches, we made the assumption that these data may be of importance in explaining the etymology of the group of names concentrated in the arid regions of Kazakhstan, which do not correspond to the present landscape. Ayapbekova (2002) also considered this issue.

The toponymic research revealed that phytonyms uncharacteristic of the current vegetation zones are predominantly concentrated in the Caspian Lowland. This territory currently receives 100 mm of precipitation per year, and it is characterized by sagebrush, saline and ephemeral-ephemeroïd vegetation. Nevertheless, medieval toponyms are often found containing the names of trees and poplars. According to the data of the map depicting the landscape-climate situation in the Middle Ages, the amount of annual rainfall in this area was about 200–250 mm, and the vegetation was in the form of fertile-cereal steppes with a mixture of meadows and woody plants (Abramova and Varushchenko 1989).

If so, there is a good reason to consider that the phytonyms associated with the names of trees were formed in connection with the period when woody plants were widespread in the Middle Ages.

Wang et al. (2019) found that the trend of changing toponyms corresponds to temperature changes (from the Jin to the Republic of China) through their research in eastern China. In Barthold's work (2002), it is written that the Mongol army led by Baty was never defeated during his campaign from Mongolia to Russia and Eastern Europe (1236–1243). This can also be directly related to the favorable climate. Because according to some researchers, in the XIII-XIV centuries, which is called "medieval pluvial", humidity increased and average annual temperatures decreased (Abramova and Varushchenko 1989).

Historical data has confirmed that in the later 15th century, the climate changed and arid climate prevailed in Central Asia. According to the data of Babur (1992), in the 15th century, he wrote that the Zeravshan river does not reach Bukhara for 3–4 months in spring. In 1431, the Uzbek Khan Abulhair invaded the city of Khorezm in the lower reaches of the Syrdarya. However, since the climatic conditions of the city adversely affected the health of the troops, they had to retreat (Barthold 1965).

## 5. Conclusion

The influence of climatic changes in Central Asia on the system of historical toponyms gives the possibility to a deeper comprehension of the evolution of the natural environment of the region. This study was focused on studying the impact of climate fluctuations on natural landscapes in the Middle Ages. As a result, it was found that the consequences of climatic changes were clearly reflected in toponyms. Climate change has led to changes in the soil, vegetation and fauna, and this information has been preserved in the semantic content of historical names. Medieval pluvial periods, particularly the abundant rainfall between the 9th and 13th centuries, show the areas that have become dry at present were wet and habitable at that time. For example, toponyms such as "Zhayik", "Mynbulak" and "Karakol" retain their natural features in their names and describe the natural conditions of that time. Medieval oikonyms such as Jalpaktal, Maimurg, Alma-Atyshkan, Farab, Karagaily give information about the climate of Central Asian settlements. In addition, the climatic conditions of the Medieval climatic optimum influenced the biodiversity of plants, soil and local terrains in Central Asia and were reflected through toponyms.

The results of the research give us the possibility to consider the toponymic system of Central Asia as an important indicator of climate changes. A deeper study of the historical geography and climatic conditions of the region can become a direction that will allow making important strategic decisions in the future with the use of toponyms.

## References

- Abramova TA, Varushchenko AN (1989) Paleogeographic situation of Kazakhstan and Central Asia in the Middle Ages. *Bulletin of Moscow University, Geography* 5 (6): 29–36.
- Ashirbekov UA, Zonn IS (2003) *Aral: The History of Dying Sea*. Dushanbe, 86 pp.

- Atasoy E, Yeginbayeva A (2017) Toponymic approach in scientific research of landscapes associated with the plant world. In: International Conference on Literature, Humanities and Social Sciences, January 2017, Manila (Philippines), 21–27. <http://doi.org/10.17758/URUAE.ED0117313>
- Ayapbekova AE (2002) Association of toponyms defining landscape features of West Kazakhstan region. Abstract of the thesis of the Candidate of Science in Geography. Almaty, 27 pp.
- Ayubov AR (2017) Ethnic settlement, historical geography and toponymy of Southern Sogdiana in the Ancient and Early Medieval Periods. Scientific notes of the B.Gafurov Khujand state academician university. Humanities 1(50). <https://cyberleninka.ru/article/n/etnicheskoe-rasselenie-istoricheskaya-geografiya-i-toponimiya-yuzhnogo-sogda-epohi-drevnosti-i-rannego-srednevekovya> [Accessed on 25.11.2024]
- Ayubov AR (2021) Sogd and Fergana: historical geography, ethnogeography, toponymy, symbiosis of cultures. Noshir, Khujand, 398 pp.
- Babkin AV (1998) Studies of changes in the state of the Aral Sea with fluctuations in water inflow. Meteorology and Hydrology 6: 103–110.
- Babur ZD (1992) Babur-name. Main editorial office of encyclopedias. Tashkent, 312 pp.
- Baldermann A, Wasser O, Abdullayev E, Bernasconi S, Löhr S, Wemmer K, Piller WE, Rudmin M, Richoz S (2021) Palaeo-environmental evolution of Central Asia during the Cenozoic: new insights from the continental sedimentary archive of the Valley of Lakes (Mongolia). Climate of the Past 17: 1955–1972. <https://doi.org/10.5194/cp-17-1955-2021>
- Barthold V (1897) Report on a trip to Central Asia with scientific purpose (1893-1894). Printing house of the Imperial Academy of Sciences, St. Petersburg, 198 pp.
- Barthold VV (1965) Works on historical geography. Publishing house Nauka, Moscow, 713 pp.
- Barthold VV (2002) Works on the History and Philology of the Turkic and Mongolian peoples. Eastern Literature of the Russian Academy of Sciences, Moscow, 754 pp.
- Beck HE, McVicar TR, Vergopolan N, Berg A, Lutsko NJ, Dufour A, Zeng Z, Jiang X, Van Dijk AIJM, Miralles DG (2023) High-resolution (1 km) Köppen-Geiger maps for 1901–2099 based on constrained CMIP6 projections. Scientific Data 10: 724. <https://doi.org/10.1038/s41597-023-02549-6>
- Bissembaev AA, Akhatov GA (2016) Golden Horde Hillforts in Western Kazakhstan. In: Bocharov S, Sitdikov A (Eds) Dialogue of Urban and Steppe Cultures in the Eurasian Space. Historical Geography of the Golden Horde, Proceedings of the VII International Scientific Conference in memoriam German Fyodorov-Davydov. Stratum plus. P. P., Kazan, Yalta, Kishinev, 74–76.
- Borzenkova II, Lemeshko NA (2006) Features of humidification of large regions of the Northern Hemisphere during global warming and cooling in the past and in the modern era on the example of the Aral-Caspian region. In: Bolgov MV (Ed.) Extreme hydrological events in the Aral-Caspian region. Proceedings of the international scientific conference, Moscow (Russia), October 2006. Nauka, Moscow, 9–23.
- Caves JK, Winnick MJ, Graham SA, Sjostrom DJ, Mulch A, Chamberlain CP (2015) Role of the westerlies in Central Asia climate over the Cenozoic. Earth and Planetary Science Letters 428: 33–43. <https://doi.org/10.1016/j.epsl.2015.07.023>
- Donada JT, Reinoso AS (2014) Toponyms as “landscape indicators”. In: Donada JT, Montagut i Montagut M (Eds). Proceedings of the XXIV ICOS International Congress of Onomastic Sciences, 1987–2016. <https://doi.org/10.2436/15.8040.01.200>

- Dorji K (2024) Storied Toponyms in Bhutan: Affective Landscapes, Spiritual Encounters, and Climate Change. In: *Himalayan Climes and Multispecies Encounters*. Routledge, London, 71–86. <https://doi.org/10.4324/9781003484394-4>
- Feng S, Liu X, Shi F, Mao X, Li Y, Wang J (2022) Humidity changes and possible forcing mechanisms over the last millennium in Arid Central Asia. *Climate of the Past* 18(5): 975–988. <https://doi.org/10.5194/cp-18-975-2022>
- Gulyamov YG (1957) History of irrigation of Khorezm from ancient times to the present day. *Khorezm. Info*. Tashkent: Academy of Sciences of the Uzbek SSR. <http://hdl.handle.net/2451/40013> [Accessed on 15.11.2024]
- Hao Z, Zheng J, Yu Y, Xiong D, Liu Y, Ge Q (2020) Climatic changes during the past two millennia along the Ancient Silk Road. *Progress in Physical Geography: Earth and Environment* 44(5): 605–623. <https://doi.org/10.1177/0309133319893919>
- Hong B, Gasse F, Uchida M, Hong Y, Leng X, Shibata Y, An N, Zhu Y, Wang Y (2014) Increasing summer rainfall in arid eastern-Central Asia over the past 8500 years. *Scientific Reports* 4(1): 5279. <https://doi.org/10.1038/srep05279>
- Ibn Hawqal, Abu-I-Kasim (1957) Book of routes and countries. Works of the V.I. Lenin Central Asian State University. Archeology of Central Asia. Tashkent, May. <https://www.vostlit.info/Texts/rus9/Haukal/text.phtml?id=12677> [Accessed on 15.11.2024]
- Itina MA (1991) Antiquities of Southern Khorezm. Works of the Khorezm archaeological and ethnographic expedition. Nauka, Moscow, 290 pp.
- Jacobson M, Pickett J, Gascoigne A, Fleitmann D, Elton H (2022) Settlement, environment, and climate change in SW Anatolia: Dynamics of regional variation and the end of Antiquity. *Plos One* 17(6): e0270295. <https://doi.org/10.1371/journal.pone.0270295>
- Jin L, Chen F, Morrill C, Otto-Bliesner B, Rosenbloom N (2011) Causes of Early Holocene desertification in arid Central Asia. *Climate Dynamics* 38(7–8): 1577–1591. <https://doi.org/10.1007/s00382-011-1086-1>
- Kaimuldinova KD, Shakirova ND, Shakirova AD, Wendt JA (2023) Traditional ecological knowledge of the Kazakh people as a prerequisite for education for sustainable development. *Pedagogy and Psychology* 56(3): 16–23. <https://doi.org/10.51889/2960-1649.2023.15.3.001>
- Kamaliddinov SS (1996) Historical geography of Southern Sogd and Tokharistan based on Arabic-language sources from the 9th to the early 13th centuries. Tashkent (Uzbekistan), 534 pp.
- Kamoliddin SS (2019) To the etymology of the toponym Baikand in the Bukhara region. Sogd collection. Saarbrücken: LAP 6: 61–75.
- Kaya MY, Dupont-Nivet G, Proust J, Roperch P, Bougeois L, Meijer N, Frieling J, Fioroni C, Özkan Altiner S, Vardar E, Barbolini N, Stoica M, Aminov J, Mamtimin M, Zhaojie G (2019) Paleogene evolution and demise of the proto-Paratethys Sea in Central Asia (Tarim and Tajik basins): Role of intensified tectonic activity at ca. 41 Ma. *Basin Research* 31: 461–486. <https://doi.org/10.1111/bre.12330>
- Kdyrnyazov OS (2017) Characteristic urbanization features of the Southern Aral in the Middle Ages. *Science and world* 12 (52): 70–73. <http://en.scienceph.ru/archives-science-and-world>
- Krachkovsky IY (1939) Journey of Ibn Fadlan to the Volga. Translation and commentary. Publishing house of the USSR Academy of Sciences, Moscow, 228 pp.
- Kushimova BA (2010) Explanatory dictionary of place names of Mangystau region. Nurly Alem, Almaty, 238 pp. <https://atau.kz/kz/book/9>

- Laiskhanov S, Kaimuldinova K, Aliaskarov D (2024) Dynamics of the Aral Sea water area on historical maps. *Geography and water resources*: 52–63. <https://doi.org/10.55764/2957-9856/2024-2-52-63.12>
- Luneau É (2019) Climate Change and the Rise and Fall of the Oxus Civilization in Southern Central Asia. In: Yang LE, Bork H-R, Fang X, Mischke S (Eds), *Socio-Environmental Dynamics along the Historical Silk Road*. Springer International Publishing, Cham, 275–299. [https://doi.org/10.1007/978-3-030-00728-7\\_14](https://doi.org/10.1007/978-3-030-00728-7_14)
- Mann ME (2002) Medieval climatic optimum. In: Munn T (Ed.), *Encyclopedia of Global Environmental Change, Volume 1: The Earth System: Physical and Chemical Dimensions of Global Environmental Change*. Wiley, Chichester, UK, 514–516.
- Maryksin DV (2013) Report on the excavations of the Jalpaktal settlement, the Baurzhan-Ayak settlement and Koshkar and Karozen burial complexes in 2012. Institute of Archeology named after A.Kh. Margulan
- Masson ME (1966) Medieval trade routes from Merv to Khorezm and Maverannahr. Works of the South Turkmenistan archaeological complex expedition. Vol. 13. *Izvestiya Turkmenskogo Filiala Akademii Nauk SSSR, Ashgabat (Turkmenistan)*, 296 pp.
- National Encyclopedia (1998) Volume 1. Nysanbaev A (Ed.). *Kazakh Encyclopedia Main Editorial Office, Almaty*, 720 pp.
- Pederson N, Hessel A, Nachin B, Anchukaitis K, Cosmo N (2014) Pluvials, droughts, the Mongol Empire, and Modern Mongolia. *Proceedings of the National Academy of Sciences* 111(12): 4375–4379. <https://doi.org/10.1073/pnas.131867711>
- Qiu N, Liu S (2018) Uplift and denudation in the continental area of China linked to climatic effects: evidence from apatite and zircon fission track data. *Scientific Reports* 8: 9546. <https://doi.org/10.1038/s41598-018-27801-7>
- Remezov SU (1701) *Drawing book of Siberia*. Tobolsk, 48 pp.
- Sabyrbekov R, Overland I, Vakulchuk R (2023) Introduction to Climate Change in Central Asia. In: Sabyrbekov R, Overland I, Vakulchuk R (Eds), *Climate Change in Central Asia*. SpringerBriefs in Climate Studies. Springer Nature Switzerland, Cham, 1–11. [https://doi.org/10.1007/978-3-031-29831-8\\_1](https://doi.org/10.1007/978-3-031-29831-8_1)
- Sandiboev AN, Shirinov TS (2021) Historical geography and localization of the Maymurg possession. Modern scientific research: current issues, achievements and innovations. In: Gulyaev GY (Ed.) *Collection of articles of the XXI International Scientific and Practical Conference*. ICNS Science and Education, Penza, 42–45.
- Savvinova AN, Filippova VV, Gadal S (2016) Geographical names as indicators of natural and climatic conditions of the Oymyakon Region (based on the study of toponyms with cold semantics). *Advances in modern science* 4(9): 160.
- Shnitnikov AV (1957) Variability of general humidity of the continents of Northern Hemisphere. *West Geogr. Society of the USSR*. Publishing House of the USSR Academy of Sciences, Moscow 16: 1–33.
- Song S, Huang L, Zhang Y, Zhang Q, Zhou F, Liu C, Chen Y, Wu Y, Zhang Y (2022) Middle Miocene climate transition in the Tibetan Plateau: identification and significance. *Geological Magazine* 159: 153–172. <https://doi.org/10.1017/S0016756821000893>
- Spampinato G, Crisarà R, Cameriere P, Cano-Ortiz A, Musarella CM (2022) Analysis of the Forest Landscape and Its Transformations through Phytotoponyms: A Case Study in Calabria (Southern Italy). *Land* 11(4):518. <https://doi.org/10.3390/land11040518>
- Span A, Duysenbaeva Z (2006) Great heritage of Great Steppe/studies and comprehensions, legends. *Nurly Alem, Almaty*, 224 pp.

- Strakhov NM (1960) Fundamentals of the theory of lithogenesis. Types of lithogenesis and their placement on the Earth's surface. Publishing House of the USSR Academy of Sciences, Moscow, 232 pp.
- Varushchenko SI, Varushchenko AN, Klige RK (1987) Changes in the regime of the Caspian Sea in endorheic reservoirs in paleotime. Nauka, Moscow, 238 pp.
- Wang Y, Wang Y, Fang L, Zhang S, Zhang T, Li D, Ge D (2019) Spatial-temporal characteristics and causes of changes to the county-level administrative toponyms cultural landscape in the eastern plains of China. Wen T-H (Ed.). PLOS ONE 14: e0217381. <https://doi.org/10.1371/journal.pone.0217381>
- William S (1854) Dictionary of Greek and Roman Geography. <https://www.perseus.tufts.edu/hopper/text?doc=Perseus%3Atext%3A1999.04.0064%3Aentry%3Doxia-palus-geo> [Accessed on 30.12.2024]
- Yin G, Hu Z, Chen X, Tiyp T (2016) Vegetation dynamics and its response to climate change in Central Asia. Journal of Arid Land 8: 375–388. <https://doi.org/10.1007/s40333-016-0043-6>
- Zhang X, Kurbaniyazov A, Kirillin G (2021) Changing Pattern of Water Level Trends in Eurasian Endorheic Lakes as a Response to the Recent Climate Variability. Remote Sensing 13(18): 3705. <https://doi.org/10.3390/rs13183705>
- Zhang Y, Kong ZC, Yan S, Yang ZJ, Ni J (2009) "Medieval Warm Period" on the northern slope of central Tianshan Mountains, Xinjiang, NW China. Geophysical Research Letters 36: 2009GL037375. <https://doi.org/10.1029/2009GL037375>

## Additional information

### Conflict of interest

No conflict of interest was declared.

### Ethical statement

No ethical statement was reported.

### Funding

This study was carried out within the programmatic project BR21882416 "Historical Geography of Central Asia" funded by the Scientific Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan.

### Author contributions

Investigation: RT, ZN. Methodology: SL. Resources: RT. Supervision: KK. Visualization: DTA. Writing - original draft: SL. Writing - review and editing: KK.

### Author ORCIDs

Kulyash Kaimuldinova  <https://orcid.org/0000-0001-7352-5586>

Shakhislam Laishkanov  <https://orcid.org/0000-0002-3353-9681>

Duman Aliaskarov  <https://orcid.org/0000-0002-7628-1246>

Zhulduz Nizamatdinova  <https://orcid.org/0000-0003-4185-809X>

### Data availability

All of the data that support the findings of this study are available in the main text or Supplementary Information.