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Mapping the Physical and Political Geography of Greater Khorasan in the 3rd–4th Centuries AH (9th–10th Centuries CE) Using GIS

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Abstract

The present study aims to provide a spatial representation of the natural, human, and political geography of Greater Khorasan in the third and fourth centuries AH, using a Geographic Information System (GIS). Drawing on the geographical-historical data found in texts from the early Islamic centuries, this research reconstructs a coherent map of Greater Khorasan, identifies its settlements, natural features, and political and Administrative boundaries of the period, and offers a framework for converting the descriptive data from historical texts into spatial data. Geographical texts of the third and fourth centuries AH contain scattered information about cities, roads, borders, and natural features, which become capable of spatial reconstruction once organized within a GIS environment. In this study, the extent and districts of Khorasan were first determined on the basis of geographical-historical texts, and a comprehensive map of its boundaries, settlements, road network, and natural features was then produced . The spatial and descriptive data extracted from geographical-historical sources — including The Best Divisions for Knowledge of the Regions by al- Maqdasi, the various works titled The Routes of the Kingdoms , and local histories — were organized as spatial data and processed in ArcGIS Pro to reconstruction map of The Greater Khorasan. The results of the study, which led to the drawing of the detailed map of settlement coordinates, natural and human features, and in particular the historical boundaries of Khorasan, show that the accounts of the geographical sources of the third and fourth centuries AH display considerable connection in their descriptions of the cities, routes, and borders of Khorasan, and that these features can be reconciled with present-day locations through the use of appropriate software. The drawing of a comprehensive map of Greater Khorasan through the integration of geographical-historical textual data offers a relevant and reliable representation of the spatial structure, historical boundaries, and natural and human elements of the region in the third and fourth centuries AH; it also demonstrates the value of mapping software for historical analysis and description in interdisciplinary research..

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1. Introduction

The region of Greater Khorasan is among the most important historical and geographical domains of the Iranian-Islamic world, having played an unparalleled role in the formation of civilisation, culture, knowledge, and political institutions in eastern Iran. For this reason, in the geographical and historical sources of the early Islamic centuries (the third and fourth centuries AH), Khorasan is recognised not merely as a geographical extent but as a broad civilisational and cultural concept whose boundaries extended from Rayy and Qumis in the west to the Oxus (Jeyhun) and Tokharistan in the east. Despite the great importance of this region in historical texts, one of the fundamental challenges in studying the history and geography of Khorasan is the lack of precise correspondence between the information recorded in the works of geographers and historians of the early Islamic centuries and the present-day locations of the region. Changes in the names of cities and districts, shifts in the courses of rivers and roads, and differences in the methods of measuring distances and determining boundaries in ancient texts have made it difficult to identify precisely the historical borders of eastern Iran and to reconstruct them on the basis of present-day data, thereby creating problems for historical, archaeological, and geographical studies.

Given that geographical and social phenomena have changed over centuries — including changes in names and, at times, in geographical locations, such as riverbeds, the locations of cities or villages, and road routes — it is necessary to examine the extent to which the information on geographical phenomena in these sources corresponds to their present-day condition. Reconciling the geographical place names of Khorasan and eastern Iran in medieval geographical works with their present-day locations can contribute to a better understanding of the region's long-term historical and geographical development.

In general, historical events have always occurred in relation to their geographical environment, and depicting these events on a map can substantially enhance historical analysis and interpretation. On this basis, the main research question is: to what extent can the descriptive data found in the historical and geographical texts of the third and fourth centuries AH be converted into spatial data within a Geographic Information System (GIS) and used to reconstruct the natural, human, and political geography of Greater Khorasan and analyse its spatial structure? The research hypothesis is that the majority of the cities, districts, roads, borders, and natural features described in these sources — despite some name changes, limited relocations of settlement centres, and transformations arising from historical and natural developments — remain capable of being reconciled with present-day locations, and that, with the use of GIS, they can be organised, analysed, and reconstructed. The main objective of the research is therefore to reconstruct the natural, human, and political geography of Greater Khorasan in the third and fourth centuries AH through the extraction and conversion of descriptive data from geographical-historical texts into spatial data, the production of a comprehensive map of the region, and the provision of a framework for the use of Geographic Information Systems in historical research and historical geography.

2. Literature Review

In studies of the historical geography of Iran, maps have been important tools for representing the locations of settlements and the boundaries of historical districts. Among such works are The Historical Geography of the Eastern Caliphate by Le Strange (Lestrange, 1994) and works by Iranian scholars such as Greater Khorasan by Ahmad Ranjbar (Ranjbar, 1984), which draw on historical-geographical information to reconcile past boundaries with present-day conditions. However, in these comparative studies the map has not been central to the analysis but has generally been treated as a visual aid, with identified place names positioned for comparison with present-day boundaries. Among other studies that have come closer to historical GIS is the Historical Atlas of Iran produced by the Geographical Institute of the University of Tehran (Nasr *et al.,* 1971). In this work spatial data were collected and numerous general maps were produced through cartographic methods; however, these maps cannot be readily tested or subjected to spatial analysis, and the perspective they provide is therefore primarily a visual representation of past locations. In other cases, the maps do not accurately depict natural phenomena or certain physical features of the region, routes and roads lack the necessary precision, and some settlements have even been omitted to the extent that the maps provide only a general impression of the region's location. The present study differs methodologically from these works, because the map is not merely a display tool but the product of a process involving the extraction of geographical data from historical texts, their location and georeferencing, digitisation, and spatial analysis using GIS tools.

Several maps from the comparative studies of Ranjbar (Ranjbar, 1984: 25), Le Strange (Le Strange, 1994: 8–10, Map 1), and the Historical Atlas of Iran (Nasr *et al.,* 1971: Map 13) were selected. By georeferencing them using control points at villages common to all four maps, the positional error between them was determined; an example is given in Table 1. These published maps have played an important role in representing the boundaries and historical divisions of the various districts of Iran and Khorasan. However, the maps were drawn mainly for historical and descriptive display purposes and lack a precise coordinate basis and georeferencing. In the present study, as noted above, the scanned images were georeferenced, and the results showed that, although the maps in question are valuable for the general representation of spatial structure and the approximate boundaries of historical districts, they require reconstruction and further spatial adjustment for precise spatial analysis and the determination of geographical boundaries. For example, based on the georeferenced Maps 1 and 2 of the Historical Atlas of Iran, a table of the geographical coordinates of their control points was prepared, and the average distance between the actual points and the corresponding points on the maps was found to be 40.87 kilometres — a substantial discrepancy for spatial analysis in GIS.

Many studies have also been published in international journals on this subject; it should be noted that these studies have made extensive use of descriptions in geographical texts for the spatial reconstruction of specific regions using GIS. Among these studies are the following:

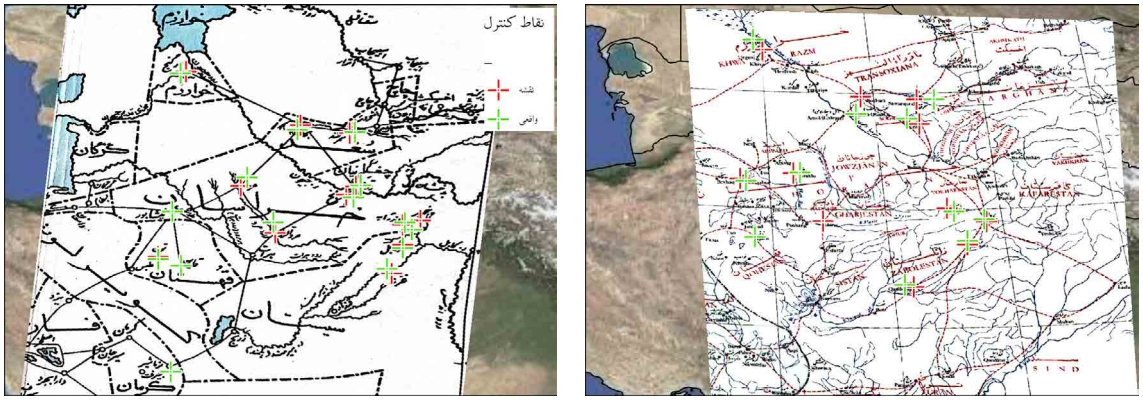


Fig. 1: Georeferenced map of the Buyid period from the Historical Atlas of Iran (right) and the Khorasan map from The Lands of the Eastern Caliphate (left) (Authors, 2026).

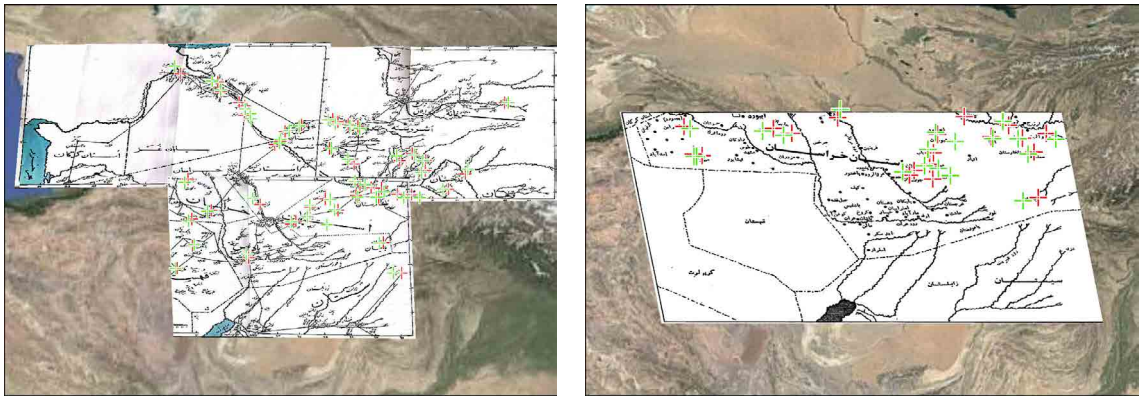


Fig. 2: Georeferenced map of Greater Khorasan by Ranjbar (right) and three historical maps from The Lands of the Eastern Caliphate (left) (Authors, 2026).

Table 1: Sample Ground Control Points Used for the Georeferencing of the Buyid Map from the Historical Atlas of Iran and Their Positional Errors (Authors, 2026).

Number	Control Points	Map Coordinates		Actual Coordinates of Points (WGS 1984)		Spatial Error Range
		Longitude	Latitude	Longitude	Latitude	KM
1	Nishabur	58.569543	36.250245	58.823234	36.15649	24.055
2	Sarakhs	60.880338	36.487391	61.167119	36.509451	26.156
3	Qaen	59.219677	33.720853	59.219677	33.720853	_
4	Harat	62.165142	34.395702	62.165142	62.165142	_
5	Qndahar	66.102719	31.547654	65.714944	31.633827	35.35
6	Bamyan	67.541796	34.960075	67.843399	34.822199	31.88
7	Ghazni	68.42937	33.374506	68.42937	33.555467	18.35
8	Kabul	69.256623	34.382721	69.153217	34.486127	16.318
9	Samarkand	66.223361	39.673696	66.971982	39.67962	66.008
10	Bukhara	63.793304	39.794337	63.592415	39.046793	86.115
11	Urgench	59.536395	41.836619	59.131386	42.276097	63.6
Mean Error Range in the Historical Atlas of Iran						40.87 KM

Cartography of Andalus Landscape: Mapping Settlements of Muslim Agricultural Colonization in Europe Applying GIS Techniques: this study examines the pattern of Muslim settlements in the southeastern part of the Iberian Peninsula (Spain). The author has sought, by identifying settlement and agricultural patterns in southeastern Iberia, to examine the territorial boundaries, population,

and communication routes of the region using Muslim and Christian literary-historical sources with the aid of GIS tools. The study is to some extent interdisciplinary, and the author, working in the field of architecture, skilfully links elements of history, archaeology, and architecture (Quesada-Garcia, 2024). In terms of its use of historical and literary sources to identify and locate settlements and convert descriptive historical data into spatial data within a GIS environment, this study provides an important methodological basis for the present article. However, its focus is mainly on the settlement patterns and their relationship to agriculture in a specific region, whereas the present study, focusing on Greater Khorasan, examines not only settlements but also natural features, the road network, and political and geographical boundaries within a single spatial framework.

Cartographic Design and Processing of Originally Printed Historical Maps for Their Presentation on the Web: This study examines methods for creating a historical atlas, drawing on examples from the mapping of the Atlas of the Czech Republic. Most of the article concerns technical cartographic issues, such as the organisation and display of layers, map legends, and matters related to map design (Jušťová & Cajthaml, 2023). This study has been used in the present article for its methods of processing, organising, and cartographically displaying historical maps, and it demonstrates the importance of the proper design of layers, map elements, and methods of presenting historical information. However, its main focus is on the design and presentation of historical atlases and the web-based display of maps, whereas the present study uses GIS not only for display but also for the extraction, location, georeferencing, and analysis of historical geographical data.

Mapping the Past with Historical Geographic Information Systems: Layered Characteristics of the Historic Urban Landscape of Nanjing, China, since the Ming Dynasty (1368–2024): This study, which covers a relatively long but compressed period, reconstructs the historical landscape of the city of Nanjing, China. The authors identify the scattered nature of historical data and the lack of an integrated platform as major problems in historical-landscape studies and argue that Historical GIS (HGIS) can help address these problems. In general, the study uses tools such as georeferencing and the digitisation of geographical-historical descriptive data to reconstruct the city of Nanjing over a relatively long period up to the present day through digitisation (Bai et al., 2024). In terms of its use of HGIS to integrate scattered historical data and convert historical geographical information into spatial layers, this study provides a suitable methodological basis for the present research. Likewise, methods such as georeferencing and digitisation employed in that study have been taken into account in designing the spatial process of the present research. However, that study focuses on the transformation of the historical landscape of the city of Nanjing, whereas the present study is regional in scale and seeks the simultaneous representation of settlements, the road network, natural features, and historical boundaries of Greater Khorasan.

3. Data Collection and Analysis Method

The research data were extracted through a library-based method from the geographical and

historical texts of the third and fourth centuries AH, including Ahsan al-Taqasim, the various works titled The Routes of the Kingdoms, The Description of the Earth by Ibn Hawqal, and local histories. The information gathered included settlements, provinces, roads, political borders, natural features, and other geographical place names. After extraction, these data were organised as spatial and descriptive data and prepared for processing in ArcGIS Pro.

The spatial coordinates of cities, villages, and other geographical features were extracted using Google Maps imagery and OpenStreetMap (OSM), and recorded in the WGS 1984 geographic coordinate system. All descriptive information for each feature — including its historical name, present name, source, location, province, and other relevant characteristics — was recorded in the attribute table, enabling connections between spatial data and historical information, the classification of features, and the performance of spatial analyses (Makhdoom *et al.,* 2013: 135).

To evaluate and reconcile the historical maps with present-day locations, the maps of al-Istakhri and Ibn Hawqal, as well as selected maps from previous studies, were georeferenced within ArcGIS Pro (Figs. 1 and 2). In this process, known cities, stable natural features, and other identifiable points were used as control points to align the historical maps with the geographic coordinate system. This made it possible to compare the historical data with present-day locations and assess the degree of correspondence between the identified places (Affek, 2013: 376; Rumsey & Williams, 2002: 1–5).

To create the spatial basis of the final map, Google Maps imagery was used to locate features, a Digital Elevation Model (DEM) and hillshade were used to display terrain relief, and Sentinel-2 land-cover data (10 m) were used for land-cover analysis (Table 2). These data, while providing an image of the present condition of the region, also made it possible to compare and analyse certain geographical features described in the historical texts.

After the historical and spatial data were integrated, the final map was prepared in the software's Layout environment. To display the information, the Symbology, Unique Values, Labeling, and Annotation capabilities were used so that features could be classified and represented according to characteristics such as province, sub-district (rustaq), historical source, and other descriptive indicators. The result of this process was a comprehensive map of the natural, human, and political geography of Greater Khorasan in the third and fourth centuries AH, which made it possible to conduct spatial analysis and a comparative examination of the historical data against the present condition (Fig. 3).

Table 2: Datasets Used in the Study (Authors, 2026).

Access	Use	Precision	Raster Layer
Google Earth Engine-Code Editor	Base layer(Map)/ Elevation ratio	90m	DEM- SRTM GL3 90m
Landcover Explorer	Cultivated land ratio	100m	Land Cover Sentinel2- 100m
Google Earth Engine-Code Editor	3D landscape	90m	Sentinel2_Terrain_VegEnhanced

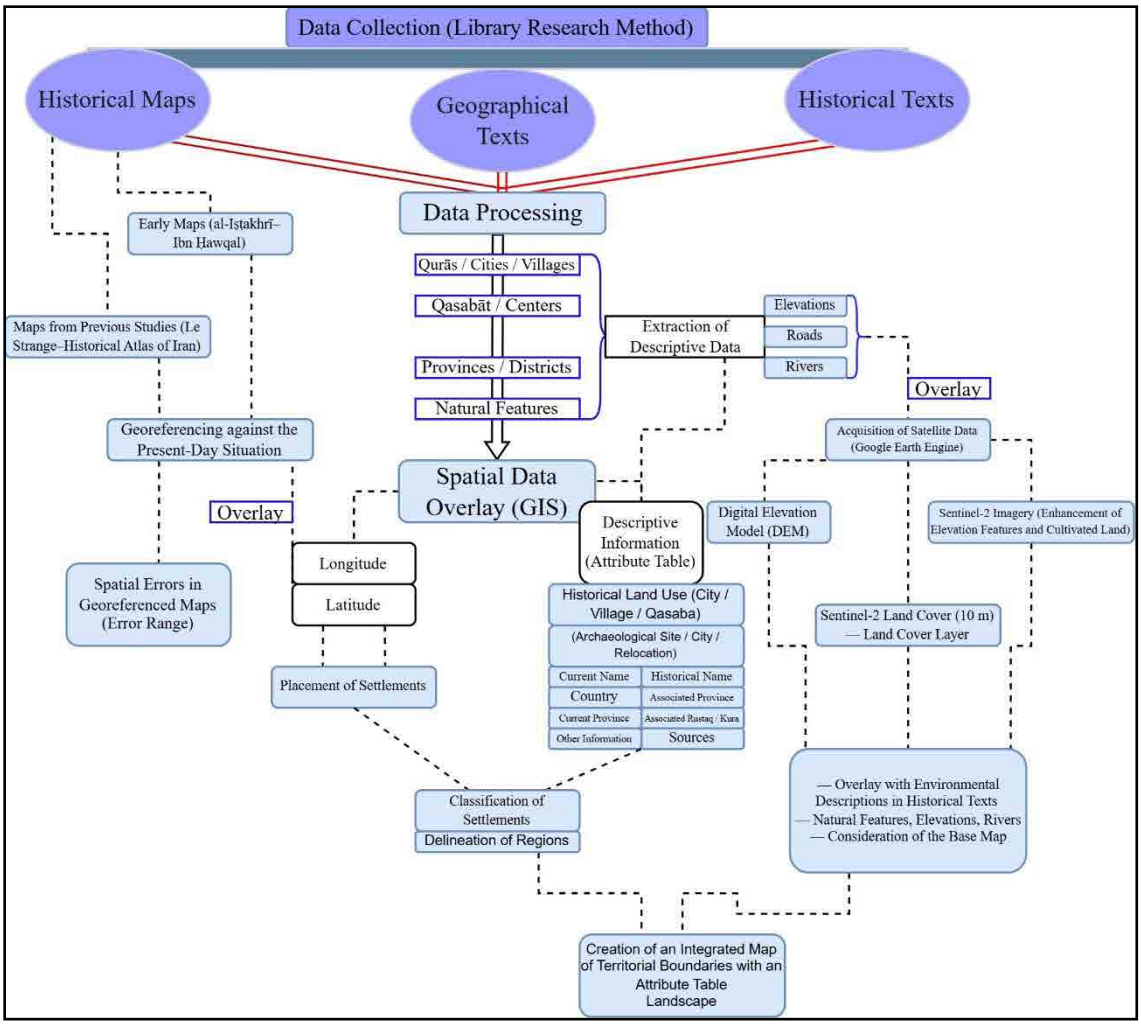


Fig. 3: Workflow of the research process for reconstructing a comparative map of the natural and political geography of Greater Khorasan using GIS (Authors, 2026).

4. Identifying the Territorial Boundaries of Greater Khorasan Based on Geographical-Historical Texts

Geographical texts such as The Routes of the Kingdoms by al-Istakhri and The Description of the Earth by Ibn Hawqal provided maps as part of their geographical descriptions. Two maps from these works, drawn to show the boundaries of Khorasan, were examined (al-Istakhri, 1961; Ibn Hawqal, 1966: 162). Although the maps are not precisely accurate, they display important information about the relationships among settlements, approximate boundaries, and certain natural features of Khorasan. Georeferencing tools were therefore used to reconcile the maps, in relative terms, with present-day coordinates. To examine the effect of the transformation type on the degree of correspondence between the historical maps and present-day coordinates, georeferencing was carried out using two methods, Affine and Spline. The Affine transformation (Fig. 4), being a linear transformation, preserves the overall geometric relationships of the map, whereas the Spline transformation (Fig. 5), by applying non-linear changes, allows for the correction of local distortions and a closer fit of the control points. As can be seen in the image,

the Spline method caused excessive warping of the map (Fig. 5). This method attempts to fit the locations of the georeferencing control points to their true coordinates; consequently, because the map was not drawn with precise coordinates, the resulting image becomes distorted from its original shape. Nevertheless, despite the loss of the original form, it is still possible to identify certain natural features, such as Lake Zarah in southern Khorasan, the highlands of Ghur, and the relationship between the course of the Oxus and the cities. In general, the purpose of employing these two methods was not to compare georeferencing algorithms, but to obtain the image with the greatest spatial correspondence for the approximate boundaries of Khorasan in the maps of al-Istakhri and Ibn Hawqal, and to use it in reconstructing the historical geography of the region.

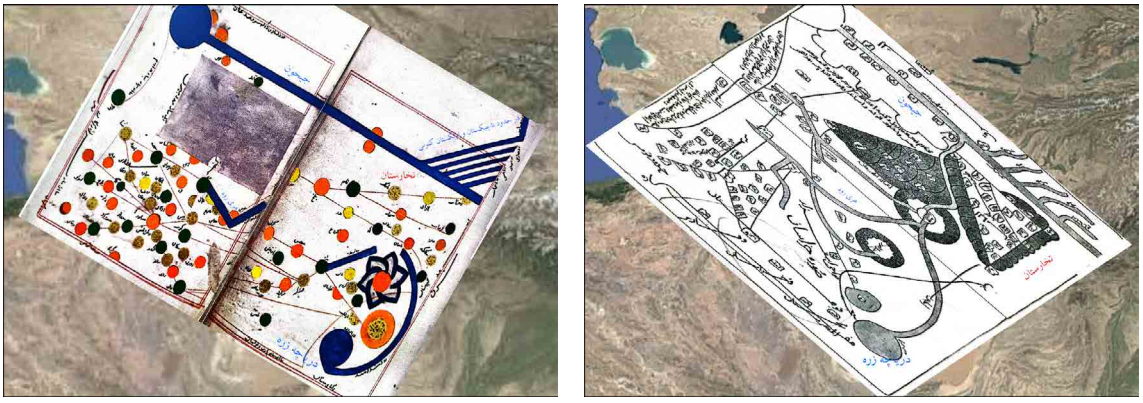


Fig. 4: Georeferenced maps of al-Istakhri (left) and Ibn Hawqal (right) using the Affine transformation. In this method, the geometric relationships and linear characteristics of the maps are preserved as much as possible (Authors, 2026).

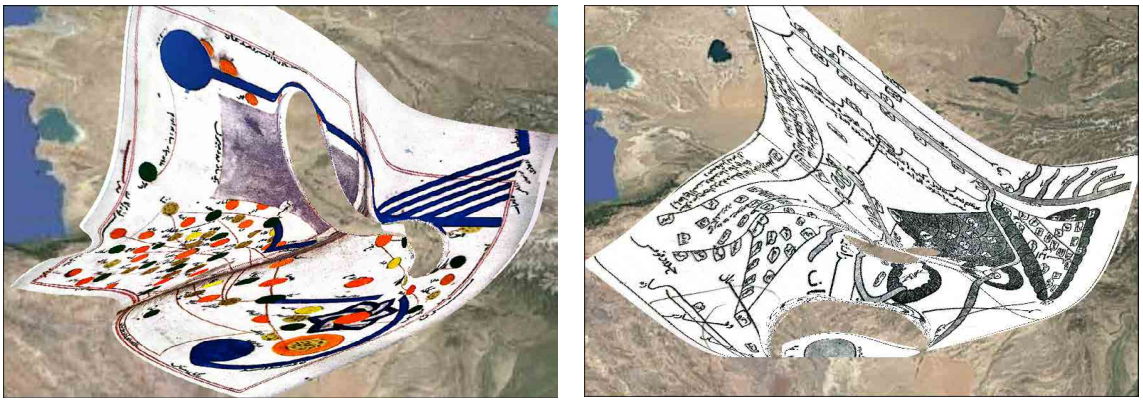


Fig. 5: Georeferenced maps of al-Iṣṭakhrī (left) and Ibn Ḥawqal (right) using the Spline transformation. The method maximises the fit to the ground control points but introduces local distortions due to the limited geometric accuracy of the historical maps (Authors, 2026).

Based on the georeferencing of the two maps above (Figs. 4 and 5), the boundaries of Khorasan may be considered as shown in Figure 6. The three present-day provinces of Khorasan in Iran, the greater part of Afghanistan, and small parts of the provinces of Mary and Ahal (Akhal) in Turkmenistan fall within the defined boundaries of Khorasan. However, the lands beyond the Oxus River, which today comprise much of Tajikistan and Uzbekistan — regions such as Khutal, Soghd, and Khwarazm are recognised in some historical-geographical works as part of Khorasan, or are mentioned as being in direct connection with it. On this basis, determining the study area

required a comparative rereading of the geographical texts and a distinction between regions that in various sources are at times considered part of Khorasan and at times independent of, or dependent on, Transoxiana.

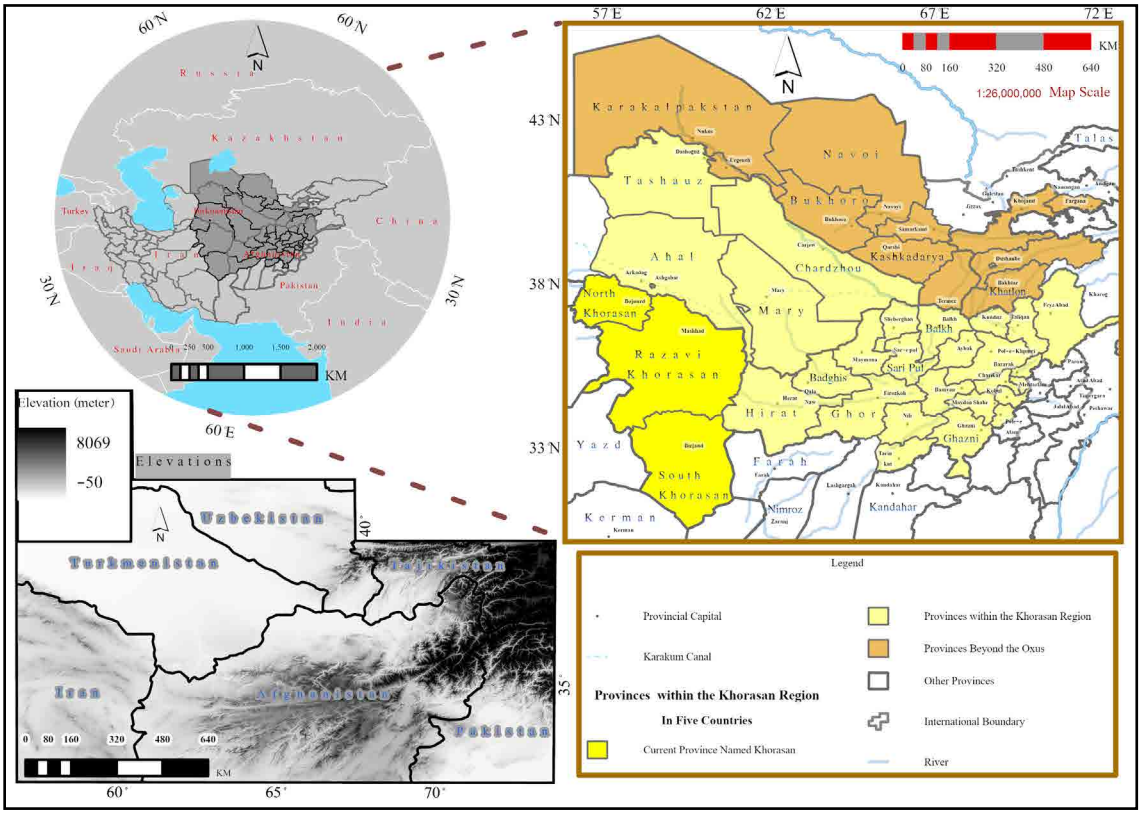


Fig. 6: Establishment of the preliminary study area based on present-day political boundaries and topographic features as the first step in reconstructing the geographical extent of Greater Khorasan (Authors, 2026).

A comparative examination of the sources shows that the boundaries of Khorasan in the third and fourth centuries AH were not fixed and differed across the various sources (Bayhaqi, 1971: 18; Sayyed Sajjadi, 2004: 67). These differences stem less from disagreement about the geographical location of the districts than from political developments, the territorial extent of governments, and the descriptive approaches of the geographers. For this reason, in the present study the boundaries of Khorasan were not determined on the basis of a single source; rather, by comparing the body of geographical and historical texts, a boundary was chosen that showed the greatest agreement with the shared accounts of the sources. On this basis, the term "Transoxiana" (Ma wara' al-Nahr) has been used solely for the lands beyond the Oxus, and only those districts whose attribution to Khorasan in the sources is supported by sufficient descriptive evidence have been included in the study area.

5. The Territorial Unity of Greater Khorasan in Ancient Geographical Texts

A comparative examination of the geographical texts of the third and fourth centuries AH shows that, although there are disagreements in determining the precise boundaries of Khorasan, most geographers agree on the general framework of the region. These differences are observed mainly

in the border areas, particularly in the eastern and northern parts, and stem less from disagreements in geographical knowledge than from political developments and changes in the territorial extent of governments in different periods.

Ibn Khordadbeh describes Khorasan as an independent land whose eastern border extends to Tokharistan and Ghazna, and which does not include Transoxiana (Ibn Khordadbeh, 1992: 4). Yaqubi, by contrast, placing Balkh at the centre of Khorasan, describes the extent of this land through its distance from the surrounding districts (Yaqubi, 1977: 63). This description shows that the author considered large parts of the region north of Balkh — namely Khutal to Soghd, and, to the east, as far as beyond Badakhshan — to be part of the political territory of Khorasan in the third century AH. Similar evidence is also found in historical sources; for example, Bayhaqi calls Herat the "midpoint of Khorasan," which reflects the role of this city in the region's communication network (Bayhaqi, 1971: 276). Moreover, the fact that this city was regarded as the midpoint of Khorasan in the author's own time, the fifth century AH, is evidence of changes in the political territory of Khorasan.

In some works, such as The Routes of the Kingdoms by al-Istakhri, the boundaries of Khorasan are extended as far as Ghur (al-Istakhri, 1968: 220). This difference can be interpreted in light of the political circumstances at the time the work was written, since the extent of Khorasan's territory changed together with the expansion or contraction of the influence of ruling governments. Al-Maqdasi, too, explicitly emphasises the conventional nature of these boundary divisions, and in places describes Transoxiana and even Sistan as connected with Khorasan (Al-Maqdasi, 1982: 379–381). Overall, comparison of these sources shows that, although the political boundaries of Khorasan are not entirely identical across the various texts, the network of cities, communication routes, and the spatial structure of the region show considerable coherence. On this basis, in the present study the study area was determined on the basis of the shared accounts of the geographical sources, rather than on the description of a single work.

5-1. Continuity and Discontinuity of the Trans-Oxus Territories with Khorasan

An examination of the geographical and historical texts of the third and fourth centuries AH shows that the relationship between Khorasan and Transoxiana was subject to the political circumstances of different periods. Although the Oxus River is recognised in most sources as the natural boundary between the two regions, in periods when both banks of the river were under unified rule, this border largely lost its political function, and spatial continuity between the two regions was strengthened. A clear example of this situation is seen in the Samanid period, when, following the defeat of the Saffarids, the territory on both sides of the Oxus was governed as a single realm for nearly a century (Gardizi, 1958: 11; Anonymous, 1983: 88–89).

Despite this political continuity, geographers did not hold identical views on the status of Transoxiana. Ibn Hawqal extends the reach of Khorasan to the districts adjoining the Oxus, and describes Bukhara as the closest city of Transoxiana to Khorasan and the gateway connecting the two lands (Ibn Hawqal, 1966: 188, 203, 218). By contrast, Ibn al-Faqih and the author of Hudud

al-Alam draw a clearer distinction between Khorasan and Transoxiana, placing Bukhara within the territory of Transoxiana (Ibn Faqih, 2014: 162; Anonymous, 1983: 106). Likewise, Beyhaqi's account places the border of the Ghaznavids within the political sphere of Khorasan (Bayhaqi, 1971: 267–270).

Comparison of these accounts shows that the disagreement among the sources relates less to the geographical location of the cities than to political changes and shifts in governmental borders. Accordingly, in the reconstruction of the historical map in this study, Transoxiana was treated as a region independent of Khorasan, but the border areas that are described in various sources as being in direct connection with Khorasan were taken into account in determining the study area.

5-2. Discontinuity and Continuity of Khwarazm with Khorasan

Khwarazm is among the districts whose place within the territory of Khorasan is disputed among the geographers of the third and fourth centuries AH. This disagreement is seen not only in determining the geographical boundaries but also in the interpretation of the political, cultural, and linguistic ties of this province with Khorasan. Nevertheless, the fullest and clearest descriptions of this province were made in the third and fourth centuries AH. Al-Istakhri and Ibn Hawqal considered the language of the people of Khwarazm to be a dialect of Khorasan (al-Istakhri, 1347: 238; Ibn Hawqal, 1345: 209); nonetheless, the Khwarazmian dialect was not intelligible to other Iranians, and between the fifth and seventh centuries AH, with the dominance of Turkic elements, this dialect also disappeared (Barthold, 1376: 163–164). Abu Rayhan al-Biruni described Khwarazm as a territory entirely separate from Khorasan (al-Biruni, 1386: 142). Al-Maqdasi is the only geographer to provide a precise account of the cities and subdivisions of Khwarazm;

He divides this province into two parts, on the left and right banks of the Oxus, respectively named Khorasania Khwarazm and Haytal Khwarazm (al-Maqdasi, 1361: 412–415). In the third and fourth centuries AH, the province of Khwarazm was always in direct connection with the Islamic world and with other parts of Khorasan; in a sense, the events occurring within its territory were always bound up with the rest of Khorasan.

In general, as noted earlier, the boundaries of Khorasan were conventional; nevertheless, political changes influenced the views of the geographers. Table 3 lists some of the provinces attributed to Khorasan whose inclusion within the boundaries of Khorasan was disputed among the geographers; al-Ya'qubi, in his work The Book of Countries, one of the earliest geographical texts, likely because of the unified Samanid presence on both sides of the Oxus, included many of the districts beyond the Oxus, and even parts of western Khorasan such as Qumis, among the territories of Khorasan. Nevertheless, the closer the geographical texts come to the fourth century AH, the more the territorial unity among certain provinces attributed to Khorasan breaks down, and geographers no longer state their attribution to Khorasan with certainty.

6-1. Political Divisions

In The Book of the Regions of the World the criteria for distinguishing one district from another

Table 3: Comparison of the Views of Third- and Fourth-Century AH Geographers on the Inclusion of Selected Regions within Khorasan (Authors, 2026).

The Best Divisions for Knowledge of the Regions 375AH	Regions of the World 372AH	The Description of the Earth 356AH	The Routes of the Kingdoms 338AH	The Routes of the Kingdoms 300AH	The Book of Precious Records 290 AH	Book of Countries 290 AH	Book of Countries 284AH	Geographer/Province
✓	_	✓	✓	✓	✓	_	✓	Qohestan
_	_	✗	✗	✗	_	✗	✓	Qumis
_	_	✗	✗	✗	✓	✓	✓	Khwarazm
_	_	_	✗	_	✓	✓	✓	Soghd
_	_	_	✗	✗	_	✓	✓	Chaghanian
_	_	_	✗	✗	_	✓	✓	Khutal
_	✗	✗	✗	✗	✗	_	✓	Sistan
✓	_	✗	✗	✓	_	_	✓	Kabulestan
_	✗	_	✗	✗	✓	✓	_	Oshrusana
_	✗	_	✗	✗	✓	✗	_	Farghana

are stated as follows: "A district is distinguished from another district in four respects: first, by difference of climate… and fourth, by difference of rulers" (Anonymous, 1983: 55). The author further considers factors such as rivers, mountains, and deserts to be influential in determining the boundaries of districts (ibid). On this basis, Khorasan was made up of an extensive territory comprising numerous provinces and rural sub-districts (rustaqs), each with its own centre and sphere of influence.

Ibn al-Faqih divides Khorasan into four parts — Nishabur, Marv, Bukhara, and Balkh — and lists the districts dependent on each (Ibn al-Faqih, 2014: 172). In this division, Herat is considered dependent on Nishapur, and Bukhara is also counted among the main divisions of Khorasan. By contrast, he makes no mention of Kabulistan, a matter that is consistent with the accounts of al-Istakhri and The Book of the Regions of the World regarding its inclusion within the territory of India (al-Istakhri, 1968: 202; Anonymous, 1983: 88, 104). These differences show that the boundaries of Khorasan changed in accordance with political and military developments. Historical sources provide similar information. Qudama ibn Jafar, in his work al-Kharaj, lists about forty districts among the tax territories of Khorasan, extending from Qohistan, Tabas, and Nishabur to Khwarazm, Sughd, Chaghaniyan, Farghana, and Taraz (Qudama, 1991: 141–155). Local histories show the same diversity. The Hakim of Nishapur at times includes Khwarazm, Transoxiana, and Qumis among the territories of Khorasan (Nishaburi, 1995: 62–66, 203), whereas Ibn Funduq, in Tarikh-i-Beyhaq, considers Khorasan an independent province and describes Qohistan, Ghor, Kabul, and Khwarazm as separate from it (Ibn Funduq, 2012: 28-29). These differences appear to reflect political transformations and shifts in the borders of Khorasan across different periods rather than error.

6-2. Differentiation of Political Divisions Based on the Affiliation of Settlements with Each Region

In the geographical texts, settlements are usually identified according to the province or district

to which they belong, just as The Book of the Regions of the World emphasises the importance of district boundaries. Accordingly, by employing the capabilities of the Geographic Information System, the attribution of each settlement to its corresponding province or district was reconstructed on the basis of the attribute-table information within the software environment. To this end, features were separated using the Unique Values capability according to province name, so that the general pattern of distribution and the approximate boundaries of each district would become apparent (Fig. 7). It should be noted, however, that in the Persian and Arabic texts of the early Islamic centuries there is no fixed definition of concepts such as city, town, and province, and each geographer presents the division of districts according to his own method (Sayyed Sajadi, 2004: 275). Al-Maqdasi, too, states explicitly that he first introduces the khura (regional divisions) and then lists the cities dependent on each, since his purpose is to explain the geography of the districts rather than merely to order the cities (Al-Maqdasi, 1982: 419).

Consequently, the attribution of certain settlements to a given province is not always definitive, and disagreement among geographers can be observed. In addition, the gap of a century between certain geographical works, together with political and administrative developments, caused the affiliation of some districts to change. On this basis, the attribution of each settlement to the province or district mentioned in the sources was extracted and plotted on the map, so that the approximate boundary of each province, and ultimately the study area of Greater Khorasan, could be determined (Fig. 8). An examination of the distribution of settlements attributed to each province shows that the political divisions of the geographers were not merely theoretical but followed a definite pattern in the distribution of settlements. The density of settlements in certain provinces such as Nishabur, Marv, Soghd, and Bukhara, in contrast to their greater dispersal in border regions such as Badghis, Ghur, and Quhistan, reflects the differing status of these provinces within the spatial organisation of Khorasan. On this basis, the attribution of each settlement to its corresponding province made it possible to draw the approximate boundaries of the political units and, ultimately, to reconstruct the extent of Khorasan (Figs. 7 and 8).

In order to better understand the natural setting of these divisions, a three-dimensional model of the study area was also prepared using Sentinel-2 imagery and the Digital Elevation Model (DEM) (Fig. 9). This model simultaneously displays the region's relief, plains, rivers, cultivated areas, deserts, highlands, and the final study basin, and reveals the role of natural factors in shaping the pattern of settlement and the boundaries of the provinces. As can be seen in Figure 9, the extensive deserts — such as the Khwarazm Desert, the Bukhara Desert, and the Jowzjan Desert — together with the mountain ranges of eastern and central Khorasan, have confined communication among the districts to specific routes. Furthermore, based on the geographers' descriptions of each settlement in Khorasan, many villages in Khorasan have changed their names; of the 271 settlements examined in this study, 56.8% have undergone changes in their names, whereas 43.2% have retained their original names. According to Figure 9, the names of settlements in the provinces of Khwarazm, Marvshahjan, Marval-Rudh, Jowzjan, Badghis, Nisa, Abivard, Zamindavar, Chaghaniyan, and parts of Tokharistan have undergone extensive name

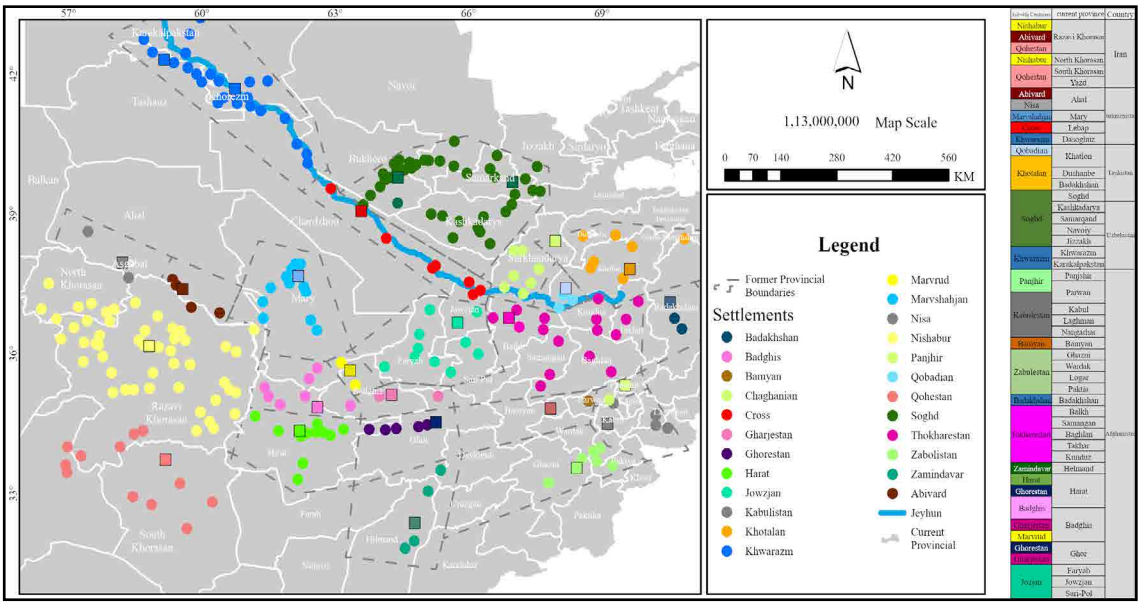


Fig. 7: Spatial representation of the attribution of Khorasan settlements to different regions based on the descriptions of third- and fourth-century AH geographers (Authors, 2026).

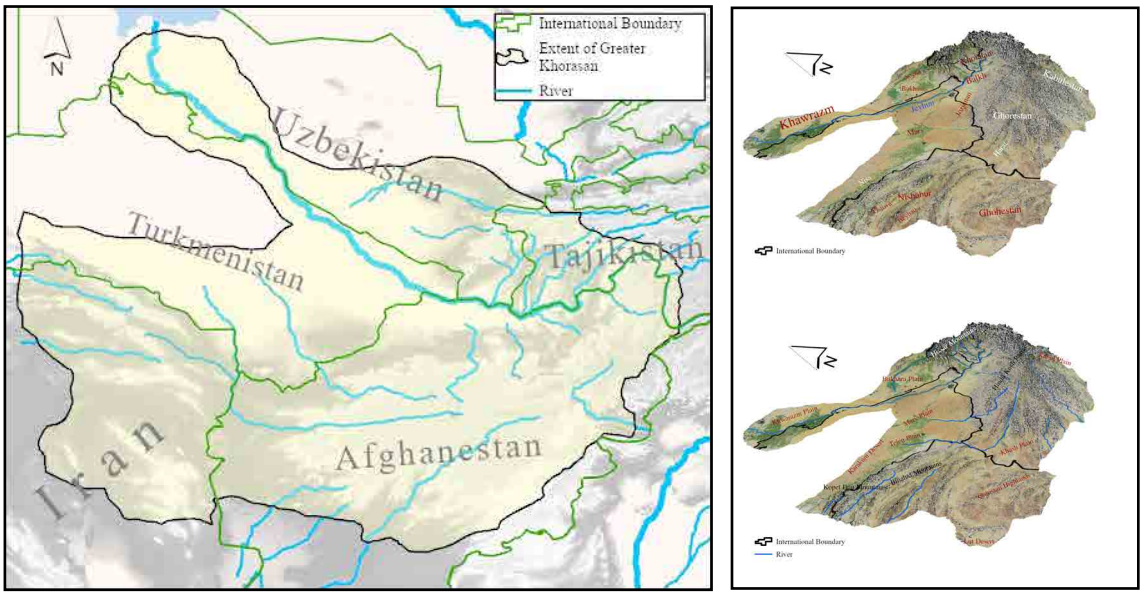


Fig. 8: Three-dimensional visualisation of the Greater Khorasan study area based on the Digital Elevation Model (DEM), illustrating the regional topographic landscape (Authors, 2026).

changes. Among the main causes of these changes are shifts in the course of the Oxus in the Khwarazm region, and, in other areas such as Nasa, Abivard, Juwzjan, and Badghis, the continual raids of nomadic peoples. It should be noted that the boundaries of the provinces of Nishabur and Quhistan, which today correspond roughly to the provinces of Razavi, North, and South Khorasan, show the least degree of change in settlement names among the villages examined; nevertheless, changes in the names of rustaqs and certain natural features are observable in this region. This spatial pattern shows that the renaming of settlements in Khorasan was not a uniform process, but occurred mainly in border and transit regions. By contrast, provinces such as Nishabur and Quhistan, which enjoyed relative political stability and greater demographic continuity, preserved

greater continuity in their geographical names. Thus, changes in names can, alongside factors such as shifts in river courses, political developments, and ethnic migrations, be regarded as indicators for reconstructing the historical and spatial transformations of Greater Khorasan.

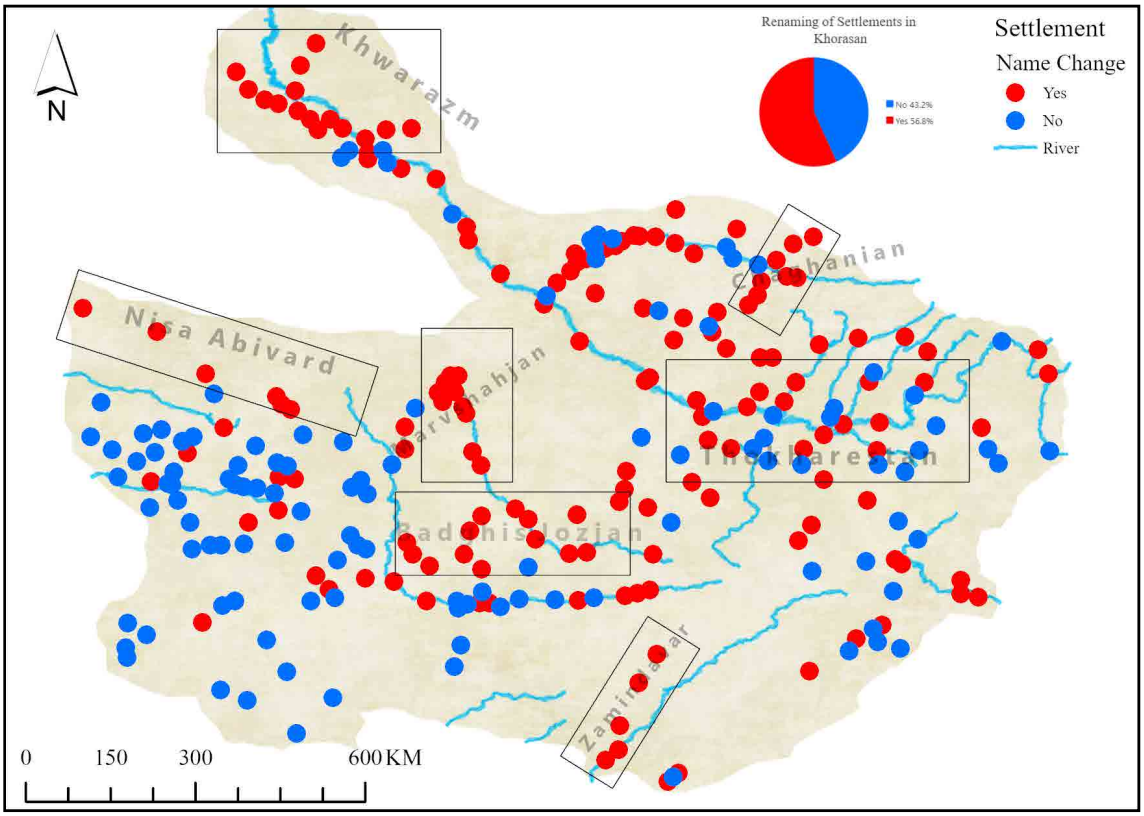


Fig. 9: Spatial Distribution of Settlements with and without Name Changes in Greater Khorasan (Authors, 2026).

6-3. Environmental Differences among the Provinces of Khorasan and Their Impact on Geographical Reconstruction

The descriptions of the geographers of the third and fourth centuries AH show that the provinces of Khorasan differed noticeably from one another in terms of natural conditions and systems of water-resource use. These differences are also important for the geographical reconstruction of the region, since the patterns of settlement, roads, and boundaries were to a great extent influenced by these natural characteristics.

For example, Marv and Khwarazm developed on the basis of extensive irrigation networks and canals branching off from the Murghab and Oxus rivers, whereas Nishapur and parts of Quhistan relied more on qanats and rain-fed agriculture (Al-Maqdasi, 1982: 465; Anonymous, 1983: 89). Likewise, the geographers' descriptions of the lush oases of Soghd and Bukhara correspond to a considerable extent with the spatial pattern of these regions in present-day spatial data (Ibn Khordadbeh, 1992: 179; al-Istakhri, 1968: 231).

By contrast, certain regions such as Badghis and Khwarazm underwent extensive changes in later centuries as a result of climatic change, shifts in river courses, and transformations in irrigation — a pattern that is observable by comparing the descriptions in historical sources with

contemporary spatial data (Barthold, 1971: 106; Lestrange, 1994: 473–486). Comparison of the geographers' descriptions with land-use data derived from satellite imagery also shows that some of the historical agricultural zones of Khorasan have continued to the present day, while extensive changes have occurred in certain regions (Fig. 10). For example, the concentration of cultivated land in the oases of Soghd, Bukhara, and Marv remains identifiable, whereas in regions such as Tajan, Nisa, and Abivard, the development of modern irrigation networks has led to an expansion of agricultural land compared with the Islamic period. By contrast, in certain areas such as Badghis, the present pattern of land use corresponds less closely with the descriptions of geographers of the early Islamic centuries — a discrepancy that may result from climatic transformations, changes in watercourses, and changes in land-use systems (Al- Maqdasi, 1982: 485; Lestrange, 1994: 442). Accordingly, recognising the environmental differences among the provinces of Khorasan, alongside the locations of settlements, allows for a more precise interpretation of spatial patterns and the reconstruction of the region's historical geography within a GIS environment.

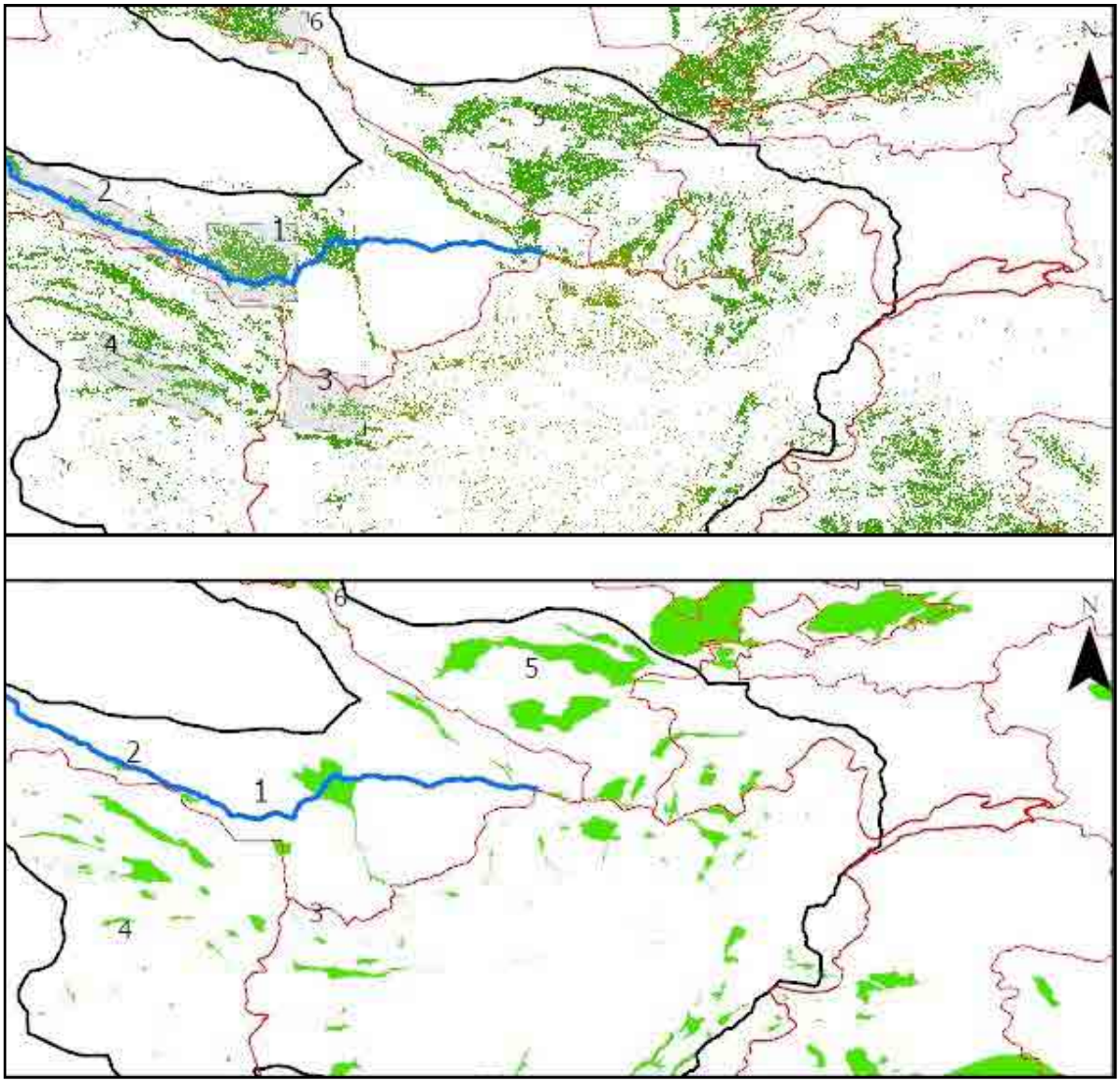


Fig. 10: Comparison of present-day and reconstructed agricultural land cover within the study area based on Sentinel-2 data and the geographical descriptions of the third and fourth centuries AH (Authors, 2026).

6-4. Communication Routes of Greater Khorasan

To identify present-day communication arteries, OSM data were used. The main trunk routes of Iran, Afghanistan, Turkmenistan, Uzbekistan, and Tajikistan within the Greater Khorasan study basin were separated from secondary roads (Fig. 11), and then reconciled with the descriptions of the geographers of the early Islamic centuries and with the routes connecting cities shown on the maps of al-Istakhri and Ibn Hawqal (Figs. 4 and 5). The communication routes were ultimately represented as a main highway and two secondary routes branching from it, designated Route 1 and Route 2. The main principle in drawing the roads was to link settlements — whether market towns (qasaba), cities, caravanserais (ribat), or small villages — along the principal routes; in their descriptions of roads, the geographers consistently referred to the distances between settlements. The roads were therefore drawn on the basis of OSM arterial-road data, the DEM elevation model, and the relative positions of the settlements (Fig. 11).

Natural conditions are also reflected in the road network of Khorasan. Despite the chronological gap between the geographical texts, the main communication routes are described with only slight differences, while greater divergence is observed in the locations of stopping stations. The evidence from the texts therefore suggests that the roads of Khorasan can be described in three categories: the main east–west highway, the routes connecting the provinces to the highway, and secondary roads. The highway of Khorasan, which formed an important part of the overland route of the Silk Road, began at Rayy and, after passing through Nishapur and Sarakhs, extended towards Marv and Bukhara or Balkh (Yaqubi, 1977: 54–55; Bastani Parizi, 2001: 199). Some secondary routes were also drawn on the basis of the geographers' descriptions, but roads whose exact stopping points could not be identified were not shown on the final map, in order to avoid hypothetical reconstruction.

Khorasan's position at the crossroads of communication routes made the region an important component of the major developments of the Islamic world. All the geographers mention the main route known as the highway of Khorasan — a route connected to the great Silk Road, which began in China and passed through Turkestan (Bastani Parizi, 2001: 200–201). According to the geographical descriptions, the highway of Khorasan passed through the main quarters (arbā') of Khorasan — Nishabur, Harat, Bukhara, Samarqand, and Balkh — and was connected by secondary routes to the other settlements of Khorasan.

Comparison of the reconstructed road network with the present-day main arteries shows that a considerable portion of today's communication axes still follow the same natural corridors as in the past. This overlap can be attributed to the continued role of the plains, mountain passes, river courses, and the avoidance of desert expanses. Although the routes have changed in detail, the overall structure of Khorasan's communication network has shown considerable continuity from the early Islamic centuries to the present.

7. The Final Map of Greater Khorasan[1]

At the outset of drawing the map, an attempt was made to establish general coordinates for the

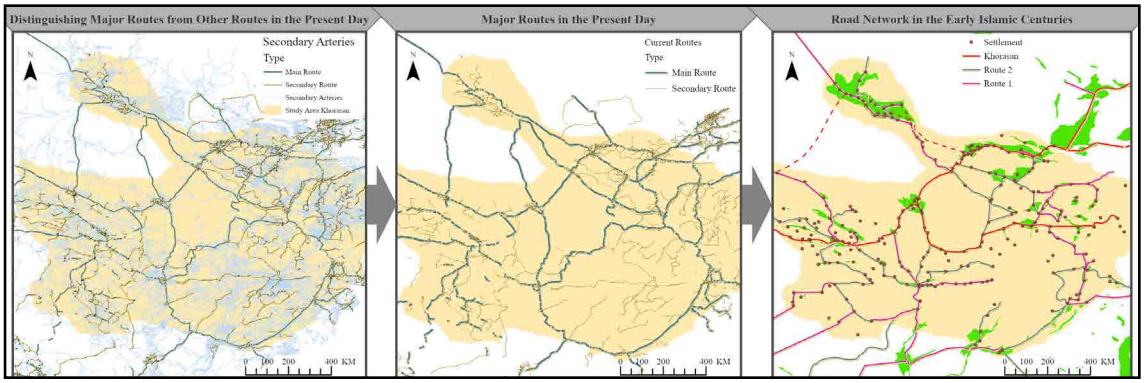


Fig. 11: Reconstructed Road Network of Greater Khorasan Based on the Contemporary Road Network and Historical Geographic Descriptions (Authors, 2026)

boundaries of Khorasan as the study area, on the basis of which the extracted data on the names of cities, villages, hamlets, rivers, and highlands were positioned. As noted earlier, many of the region's natural boundaries remain as they were in the past; the highlands, for example, may be counted among the main factors shaping the transformations of Greater Khorasan. For drawing the map, the present-day spatial base was therefore used with the aid of Google Maps imagery (Table 2), and the natural features and other place-names were subsequently drawn upon it. Given the very large scale of the map (approximately one million square kilometres on a single A4 page), an effort was made to avoid overcrowding the map with place names as far as possible. The highlands were shown on the map using a two-dimensional satellite elevation layer to enhance its visual presentation; likewise, the present agricultural basin was applied in green, with some adjustments also made on the basis of the geographers' descriptions in the ancient texts (Fig. 10). Present-day cities were shown with separate symbols, and the present political boundaries were also applied to the map. The former names of regions, villages, highlands, rivers, and lakes were shown in black and dark blue, while, for example, the present name of a city or region was placed in red. Likewise, to provide a clearer overall understanding of interconnected regions, the roads mentioned between regions and villages in the geographical texts were also drawn.

8. Conclusion

The present study, focusing on the geographical sources of the third and fourth centuries AH and using GIS software, sought to reconstruct the boundaries and spatial structure of Greater Khorasan. Analysis of the geographers' descriptions — in particular the various works titled The Routes of the Kingdoms and works containing maps such as The Description of the Earth by Ibn Hawqal — showed that, although the boundaries of Khorasan are not uniform or fixed across the various texts, a coherent network of cities, districts, routes, and natural boundaries recurs throughout these works and is capable of being converted into spatial data.

A comparative examination of the historical data against present-day locations showed that a considerable portion of the geographical place names of Greater Khorasan — particularly the main cities, important districts, and natural elements such as mountain ranges, plains, and riverbeds — have retained their spatial continuity to this day. Many discrepancies and differences

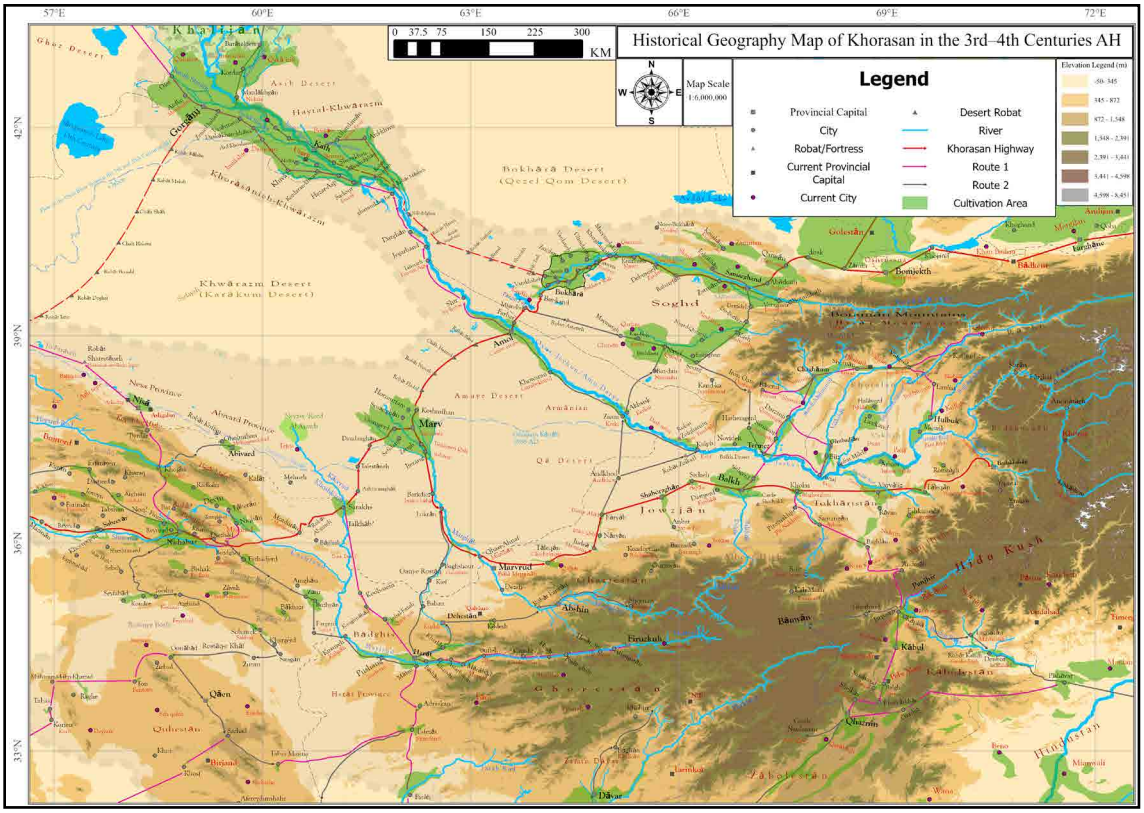


Fig. 12: Map of Greater Khorasan (Authors, 2026).

in nomenclature, shifts in river courses, and changes in the centrality of certain districts could be identified and explained through GIS analysis. It was also found that, despite differences among geographers' views regarding the precise boundaries of Khorasan and its border with Transoxiana, their descriptions of distances, routes, and the position of cities display a notable degree of coherence.

The process of reconstructing the historical map in ArcGIS Pro showed that the descriptive data of geographical texts, when systematically extracted and organized within a GIS framework, have considerable potential for representing the spatial structure of the past.

The final map produced offers a relatively precise and reliable picture of the extent of Greater Khorasan in the medieval Islamic period — a picture that can serve as a basis for future historical, geographical, archaeological, and interdisciplinary studies, and can also help clarify certain mistaken impressions regarding the boundaries of Khorasan, its communication routes, and the position of its various districts in the past. In general, the findings of this study show that the geographical data of the medieval centuries, despite their shortcomings and scattered nature, have substantial potential for reconstructing the spatial structure of the past, and that the use of GIS is an effective tool for converting these data into a precise and analysable representation of Greater Khorasan.

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Author Contributions

Both authors contributed equally to the preparation of this article, with each contributing 50%.

Conflict of Interest

The authors declare that they have no conflict of interest regarding the authorship or publication of this article.

Endnote

The map file, in TIFF format, and the settlements of Khorasan broken down in Excel, are available for download and review at: https://zenodo.org/records/21775004?token=eyJhbGciOiJIUzUxMiJ9.eyJpZCI6ImY1MjMxZTIyLTM1ZmYtNGRlMi1hMDIxL-WNhMWNkOTZjOWE2NSIsImRhdGEiOnt9LCJyYW5kb20iOiI1ZWFiNDZjNDI2MTc1M2E3MmY2ZWYyM2I5MmI1ZGY-wMSJ9.nIkdwq_t3HOmAqgs9CD6Wz-GZPUCs7UJY099EkcBIFEwxf8Jh6Gnh9Pfw0gLa7T0TYJkBwZYu6APyv4ek-Za0g

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نقشه‌نگاری جغرافیای طبیعی و سیاسی خراسان بزرگ در سده‌های سوم و چهارم هجری‌قمری (نهم و دهم میلادی) با استفاده از سامانهٔ اطلاعات جغرافیایی (GIS)

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چکیده

پژوهش حاضر با هدف بازنمای فضایی و نقشه‌نگاری جغرافیای طبیعی، انسانی و سیاسی خراسان بزرگ در سده‌های سوم و چهارم هجری‌قمری با بهره‌گیری از سامانهٔ اطلاعات جغرافیایی (GIS) انجام شده است. این پژوهش با استفاده از داده‌های جغرافیایی-تاریخیِ متون سده‌های ابتدایی اسلامی، به بازسازی نقشه‌ای منسجم از خراسان بزرگ و شناسایی استقرارگاه‌ها، پدیده‌های طبیعی و مرزهای سیاسی و انسانی آن دوره پرداخته و چارچوبی برای تبدیل داده‌های توصیفی متون تاریخی به داده‌های مکانی ارائه می‌کند. متون جغرافیایی سده‌های سوم و چهارم هجری‌قمری حاوی اطلاعات پراکنده‌ای دربارهٔ شهرها، راه‌ها، مرزها و عوارض طبیعی هستند که با سازمان‌دهی در محیط GIS قابلیت بازسازی فضایی پیدا می‌کنند. در این پژوهش ابتدا محدوده و ناحیه‌های خراسان براساس متون جغرافیایی-تاریخی تعیین و سپس نقشه‌ای جامع از حدود، استقرارگاه‌ها، شبکهٔ راه و عوارض طبیعی آن ترسیم شد. داده‌های مکانی و توصیفی استخراج‌شده از منابع جغرافیایی-تاریخی، ازجمله «احسن التقاسیم مقدسی»، «مسالک الممالک‌ها» و تواریخ محلی، پس از سازمان‌دهی در قالب داده‌های مکانی در محیط ArcGIS Pro پردازش و برای بازسازی نقشهٔ خراسان بزرگ به‌کار گرفته شد. نتایج پژوهش که منجر به ترسیم نقشه‌ای دقیق از مختصات استقرارگاهی، عوارض طبیعی، انسانی و به‌ویژه حدود تاریخی خراسان شد، نشان می‌دهد، روایت‌های منابع جغرافیایی سده‌های سوم و چهارم هجری‌قمری در تعیین شهرها، مسیرها و مرزهای خراسان از انسجام بسیار برخوردارند و با استفاده از بستر نرم‌افزاری قابل تطبیق با موقعیت امروزی می‌باشند. ترسیم نقشه‌ای جامع از خراسان بزرگ با تلفیق داده‌های متون جغرافیایی-تاریخی، بازنمایی منسجم و قابل‌اتکایی از ساختار فضایی، حدود تاریخی و عناصر طبیعی و انسانی این سرزمین در سده‌های سوم و چهارم هجری‌قمری ارائه می‌دهد؛ همچنین لزوم استفاده از نرم‌افزارهای ترسیم نقشه برای تحلیل و توصیف‌های تاریخی را به دانشجویان تاریخ در پژوهش‌های میان‌رشته‌ای را نمایان می‌سازد.

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