



Quantitative Geographical Analysis Of The Ancient Civilizations Of Iraq

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Abstract: The study aims to draw global attention to the innovative geographical approaches that distinguished the ancient civilizations of Iraq. By employing mathematical and statistical techniques to analyze the spatial distribution of cities—methods somewhat analogous to modern Geographic Information Systems (GIS)—the research examines the locations of three pivotal cultural capitals (Ur, Babylon, and Ashur) within this framework. Through calculating their spatial mean, the findings reveal that the Babylonian civilization uniquely excelled in applying quantitative geographical methods. The spatial mean was identified near the ancient city of Babylon, approximately 200 kilometers from its location, despite the Babylonian Empire's territorial reach extending far beyond the administrative boundaries of modern Iraq. Historical records indicate that the empire encompassed parts of present-day Iran, Turkey, and Syria, stretching westward to the Mediterranean Sea. This study underscores the advanced geographical planning and analytical sophistication of the Babylonians, highlighting their pioneering role in integrating quantitative spatial analysis a precursor to contemporary GIS methodologies.

Keywords: Geographical analysis, quantitative geography, Iraqi civilizations, geographic information systems.

1. INTRODUCTION: Iraq has historically been and remains the cradle of civilizations. Its distinctive geographical diversity, encompassing varied terrains, waterways, and flora from north to south and east to west, has directly shaped its rich natural resources. These resources provided humanity with the

foundation to build civilizations whose intellectual and cultural legacies have endured across millennia.

In the northern part of Iraq, particularly the semi-mountainous zone, a pronounced geographical diversity is evident. This area features rolling hills, fertile plains suitable for agriculture, and tributaries descending from adjacent mountain ranges, alongside natural springs and seasonal rainfall. The semi-mountainous climate, characterized by moderate precipitation, transitions to drier conditions farther south. This environmental gradient fostered the rise of the Assyrian civilization [4].

The central region, marked by the confluence of the Tigris and Euphrates rivers, owes its agricultural fertility to its low-lying, flat topography and nutrient-rich alluvial soils deposited by river sedimentation (Abu Subai', 2009, p. 62). These mineral-rich soils were exploited for agriculture, leading to the emergence of the Akkadian and Babylonian civilizations (Postgate, 1992, p. 105). While scholars debate the precise location of Akkad, this study focuses on Babylon, whose geographical centrality and advanced urban planning underscore its historical significance.

The southern region's vast wetlands, such as the Al-Hammar Marshes, created a biodiverse ecosystem critical to sustaining Sumerian society. These marshes provided resources for fishing, livestock rearing, and vegetation used in constructing dwellings and feeding livestock. Combined with fertile soils and flat plains, these factors catalyzed the birth of Mesopotamia's earliest civilization: the Sumerians. This underscores the pivotal role of geography in shaping civilizations, as exemplified by the Mesopotamian cradle (Potter, 2009, p. 74).

2. Justifications for Selecting the Topic

This research represents a critical step in highlighting the scientific contributions of ancient Iraqi civilizations to the field of quantitative geography. Findings suggest that the Babylonian civilization pioneered the use of geographic coordinate systems, reflecting the sophistication of scientific thought during that era. The study underscores the urgent need for expanded fieldwork utilizing modern technologies to uncover buried scientific truths. A key justification for this research is its potential to reveal hidden scientific insights from ancient Mesopotamian civilizations through empirical data, despite the many missing or ambiguous historical links. These gaps have further motivated the researcher to pursue results that bridge historical understanding with contemporary analytical frameworks.

3. Research Problem

The central research question is formulated as follows: Did ancient Iraqis employ geographic coordinates (quantitative geography) to select the locations of their capitals (Ur, Babylon, Ashur), or did they rely on other factors?

Subsidiary questions include:

1. Which ancient Iraqi civilization(s) utilized geographic coordinate systems?
2. What was the accuracy of these systems compared to modern equivalents?

4. Research Hypothesis

The primary hypothesis is:

Ancient Iraqis employed mathematical methods to determine the locations of their capitals, while also integrating other geographical factors.

Sub-hypotheses:

1. The Babylonian civilization, distinguished by its expertise in arithmetic and surveying, utilized geographic coordinates for site selection.
2. The accuracy of these methods can be considered high relative to the technological and intellectual advancements of the time.

5. Spatiotemporal Boundaries of the Study

Spatial Boundaries:

The study focuses on Mesopotamia (the Fertile Crescent), corresponding to modern-day Iraq and adjacent territories, spanning the area between longitude 24°50'E and latitude 38°28'N (see Map 1). This includes ancient kingdoms and cities such as Ur, Eridu, Kish, Lagash, Nippur, Uruk, Larsa, Sippar, Isin, Akkad, Babylon, Nippur, Ashur, Kalhu, Nimrud, Khorsabad, and Dur-Sharrukin.

Temporal Boundaries:

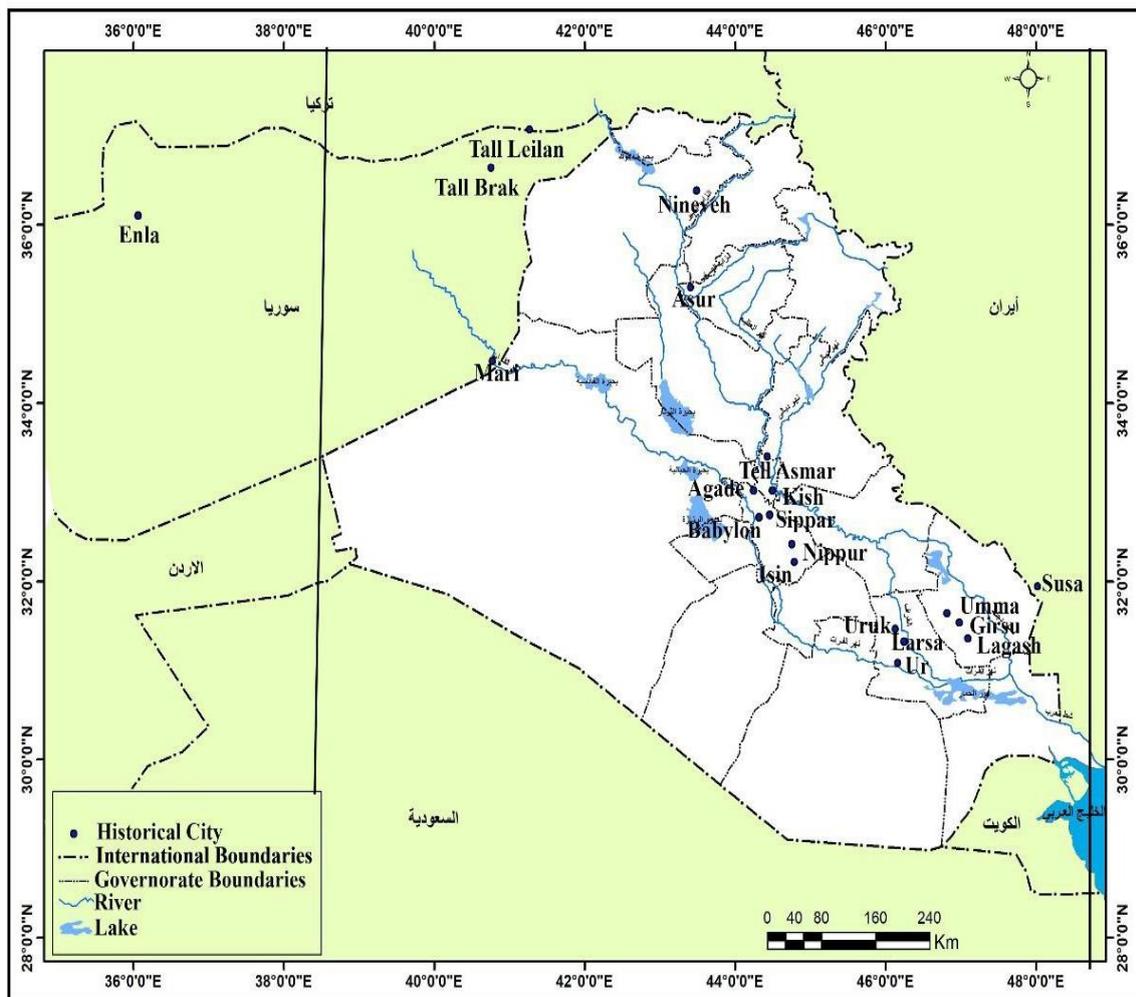
The timeframe spans from 4000 BCE, encompassing the rise and development of early Mesopotamian civilizations.

6. Methodology

The study adopts a triangulated methodological approach:

1. **Descriptive Method:** To contextualize historical and geographical phenomena.
2. **Quantitative Method:** To analyze spatial data, including coordinate systems and mathematical models.
3. **Cartographic Method:** To reconstruct ancient geographical layouts using historical maps and GIS tools.

Map (1): Spatial Boundaries of the Study Area



Source: Map created by the author, based on data from the Republic of Iraq, Ministry of Water Resources, General Authority for Survey (1995), Baghdad, Iraq.

7. Scientific Concepts Related to the Research

7.1. Geographical Analysis

Geographical analysis involves conducting spatial studies and examining spatial relationships between geographical phenomena using specialized techniques, such as Geographic Information Systems (GIS) and remote sensing. This approach aims to understand the distribution of geographical phenomena across space and time, facilitating informed decision-making in fields like urban planning, natural resource management, and transportation (Longley et al., 2015, p. 103).

7.2. Quantitative Geography

A subfield of geography, quantitative geography employs statistical methods to analyze geographical phenomena. It seeks to transform geography from a descriptive discipline into a scientific one by applying mathematical and statistical techniques to study spatial distributions. Emerging during the Quantitative Revolution of the 1950s–1960s, this approach emphasizes precision, generalization of results, and

identification of factors influencing spatial patterns (Fotheringham et al., 2000). Today, quantitative geography is a cornerstone of contemporary geography, utilizing scientific methodologies to develop laws and theories across both physical and human geography (Al-Saleh & Al-Saryani, 2014, p. 12).

7.3. Geographic Information Systems (GIS)

GIS is a powerful computational tool for studying spatial phenomena, enabling researchers to overcome challenges in data collection, analysis, and visualization across diverse fields. Defined as "a computer-based system that uses specialized software to input, manage, process, analyze, and display geographically referenced data," GIS integrates spatial data (e.g., coordinates, attributes) with non-spatial information (e.g., demographic statistics) (Al-Bannai, 2019, p. 21). Its capabilities include mapping large-scale phenomena, detecting spatial trends, and supporting evidence-based policymaking.

8. Civilizations of Mesopotamia

8.1. The Sumerian Civilization

The Sumerian civilization stands as one of the earliest known human civilizations, epitomizing an urban

lifestyle characterized by advanced communication systems, labor organization, land management, and other defining features. Culturally, it encompassed social, economic, and technological innovations that distinguished it from contemporaneous societies (Dahham, 2022, online).

Emerging in the southern Mesopotamian floodplain—specifically the Sha’ar Plain—this civilization flourished due to the region’s fertile soil, abundant water resources, and temperate climate. These conditions attracted migratory tribes from the Arabian Peninsula and facilitated groundbreaking advancements, including irrigation systems, agricultural development, astronomical observations, the creation of the first known calendar, and the division of the circle into 360 degrees. Additionally, the Sumerians pioneered clay-based record-keeping, cartography, and administrative techniques (Al-Toubal, 2007, p. 38).

Archaeological evidence suggests the Sumerians settled in southern Iraq during the Ubaid period (4000–3500 BCE) (Amin, 2004, p. 86). Their territory spanned approximately 25,000 km² along the Euphrates River, which followed a more easterly course than today, extending from south of modern Baghdad to the Arabian Gulf. This geography fostered the rise of 13 major citystates, including Sippar, Kish, Akshak, Larsa, Uruk, and Ur. However, competition over irrigation rights and agricultural land often led to inter-city conflicts, undermining long-term political stability (Qasha, 2010, p. 23).

8.2. The Akkadian Civilization

The Akkadian civilization emerged in northern Sumer, founded by Semitic tribes (Akkadians) who migrated from the Arabian Peninsula and settled in Mesopotamia during its early periods. Initially occupying the western bank of the Euphrates River between Deir ez-Zor and Hit, they later expanded southward into the territories surrounding Babylon. Sargon of Akkad (c. 2350 BCE) established the Akkadian state after subduing Sumer, instituting the concept of empire by appointing local governors to administer regions under Akkadian authority. He also introduced permanent irrigation systems to southern Mesopotamia, enhancing agricultural productivity (Al-Sousa, 1986, p. 13).

Sargon consolidated his rule over the lands stretching from Sippar to Opis, leveraging the strategic location of his capital, Akkad (Qasha, 2010, p. 30). His territorial expansion northward underscored the region’s agricultural and geopolitical significance, as evidenced by the later adoption of Akkad as a capital by the Kassites. The archaeological site of Tel Aqarqouf, near modern Baghdad, stands as a testament to this era (Al-

Sousa, 1956, p. 16).

8.3. The Babylonian Civilization

The Babylonian civilization emerged in the city of Babylon, situated on the banks of the Euphrates River approximately 96 kilometers south of modern-day Baghdad (World Book, 1970, p. 9). The Babylonians belonged to Semitic tribes who migrated eastward into central Mesopotamia, settling in regions such as Babylon. Modern historians refer to them as “Eastern Canaanites” or Amorites, distinguishing their socio-political structures from earlier Sumerian city-states. Notably, their divergent concepts of land ownership often sparked conflicts among independent polities (Hariri, 2001, p. 477).

Over time, the Babylonian state coalesced under influential rulers such as Hammurabi (r. 1792–1750 BCE), renowned for his comprehensive legal code. Hammurabi expanded his kingdom’s territorial reach to the Arabian Gulf, consolidating administrative control and fostering cultural and economic integration across Mesopotamia.

8.4. The Assyrian Civilization

The Assyrian civilization traces its origins to the decline of the Third Dynasty of Ur (c. 2000 BCE), enduring until the mid-second millennium BCE. During this period, Semitic Assyrian tribes established an independent political entity in northern Mesopotamia (Encyclopædia Britannica, 1768, p. 79)

Prominent Assyrian rulers, such as Sargon II (r. 722–705 BCE), founded dynasties and established multiple capitals, including Ashur, Nineveh, and Kalhu. Sargon II also constructed a new capital, Dur-Sharrukin (modern Khorsabad), located approximately 24 kilometers northeast of Nineveh. Other strategically significant capitals included Bab Lukal and the Gate of Shamash—the latter likely named after the Mesopotamian sun deity (Al-Sharif, 2006, p. 123). Assyrian provinces were administered under varying governance structures, reflecting localized authority (Al-Rashid, 1985, p. 31).

Geographical Classification of Mesopotamian Civilizations:

1. Northern: Assyria (Ashur, Nineveh).
2. Central: Akkad and Babylon.
3. Southern: Sumer (Ur, Uruk).

Fertile river valleys and strategic locations catalyzed agricultural prosperity, economic growth, and intellectual advancements across these regions.

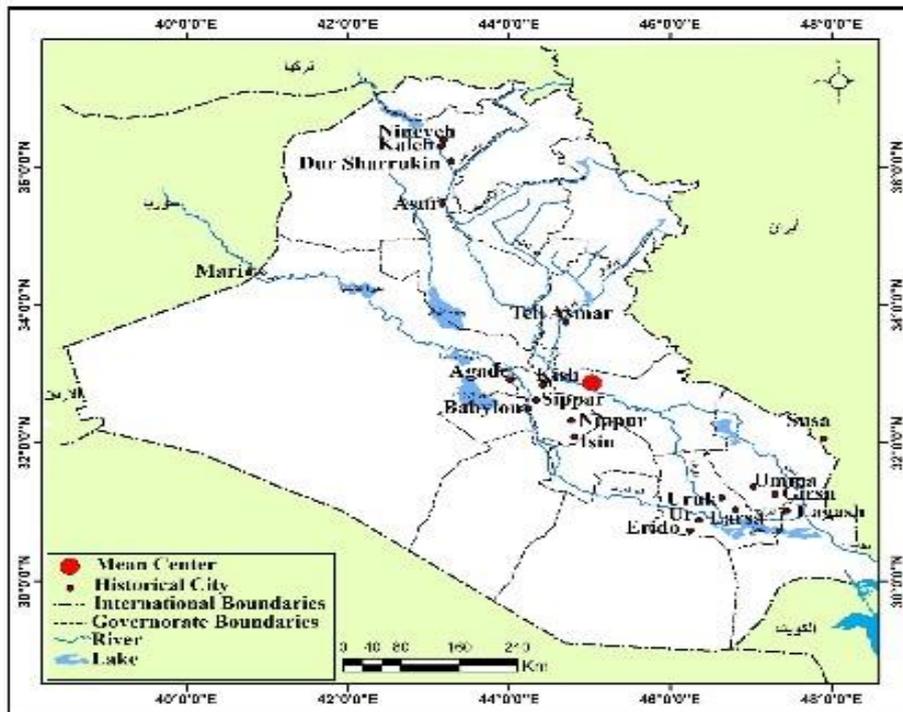
9. Testing the Spatial Mean of Mesopotamian Capitals Using GIS

As illustrated in Map (2), the territorial extent of the Sumerian civilization under the Third Dynasty of Ur

reveals that the spatial mean of its key cities was located in central Mesopotamia. This spatial mean diverges significantly from the modern geographical position of Ur, situated farther south, with a distance of approximately 500 km between the two points. This discrepancy suggests that the Sumerians did not

employ coordinate systems to site their capital. Instead, their locational choices were driven by natural factors, including proximity to water resources, fertile soils, and flat terrain, alongside other environmental and strategic considerations.

Map (2): Spatial Mean of Cities within the Sumerian Empire Derived via GIS Analysis



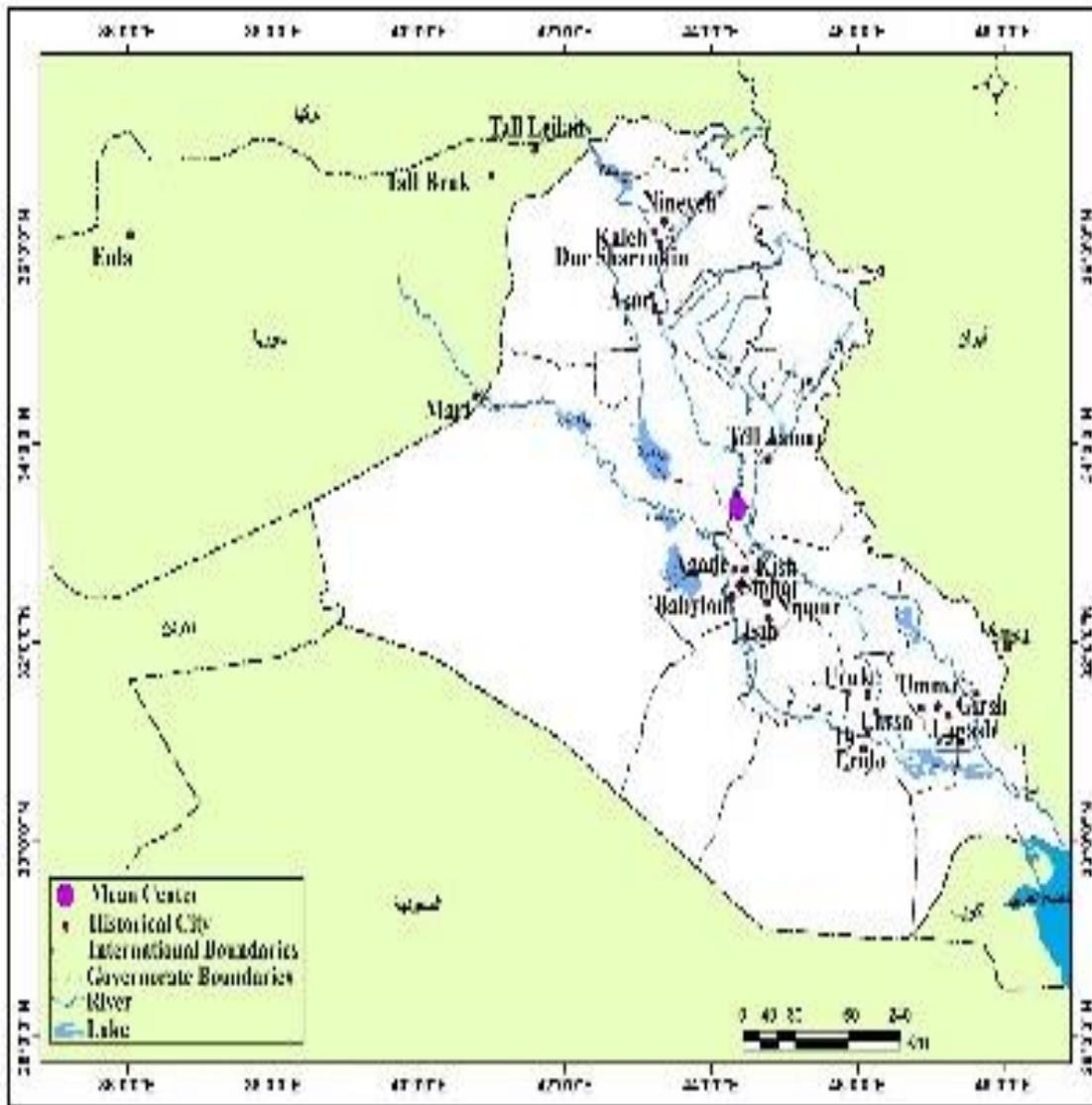
Source: Map created by the author, adapted from Al-Sabbani (2022), *Climate and Civilization in Mesopotamia: A Case Study* (p. 158).

Map (3): Spatial Mean of Cities within the Babylonian Empire Derived via GIS Analysis

"Map (3) illustrates the spatial mean (geometric center) of cities under the Babylonian Empire, calculated using Geographic Information Systems (GIS). The spatial mean aligns closely with the historical location of ancient Babylon, with a displacement of approximately

200 km between the calculated mean and the modern site. This proximity strongly suggests the Babylonians employed quantitative geographic coordinates—a precursor to modern GIS methodologies—in siting their capital. Babylon’s strategic placement, informed by advanced spatial analysis, underscores its role as a global intellectual and cultural beacon. Additional geographical factors, such as proximity to the Euphrates River and fertile alluvial plains, further informed their urban planning (Author’s analysis, 2023; adapted from Al-Sabbani, 2022, p. 158)."

Map (3): Spatial Mean of Cities within the Babylonian Empire Using GIS

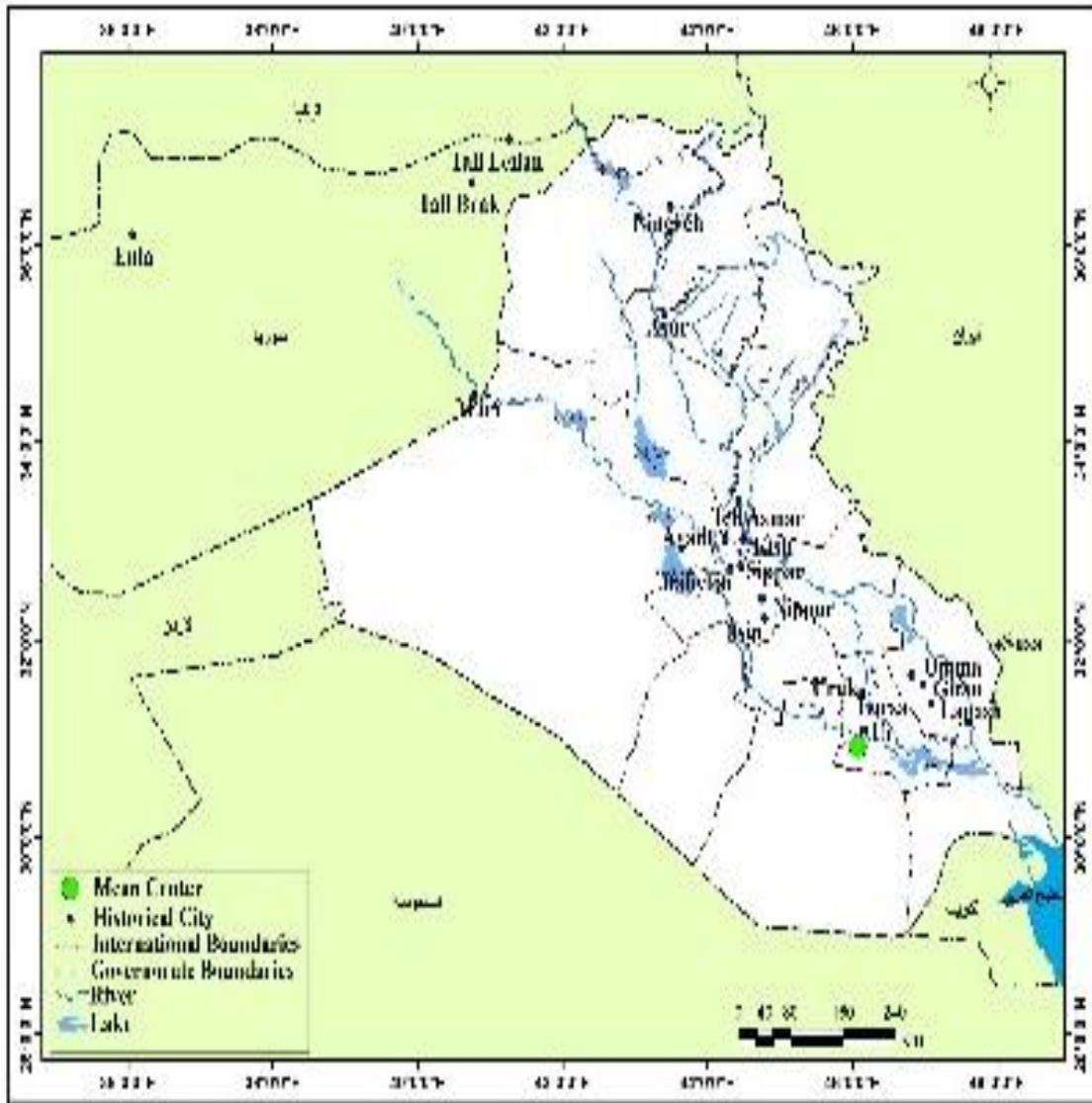


Source: Map created by the author, adapted from Al-Sabbani (2022), *Climate and Civilization in Mesopotamia: A Case Study* (p. 166).

"Map (4) delineates the territorial extent of the Assyrian Empire alongside the spatial mean (geometric center) of its cities, derived via Geographic Information Systems (GIS). The spatial mean lies approximately 750

km from the modern geographical locations of Assyrian capitals in southern Iraq. This significant displacement indicates that the Assyrians did not employ coordinate systems for siting their capitals. Instead, their urban planning relied solely on other geographical factors, such as strategic military positioning, access to trade routes, and defensible terrain (Author's analysis, 2023; adapted from Al-Sabbani, 2022, p. 166)."

Map (4): Spatial Mean of Cities within the Assyrian Empire Using GIS



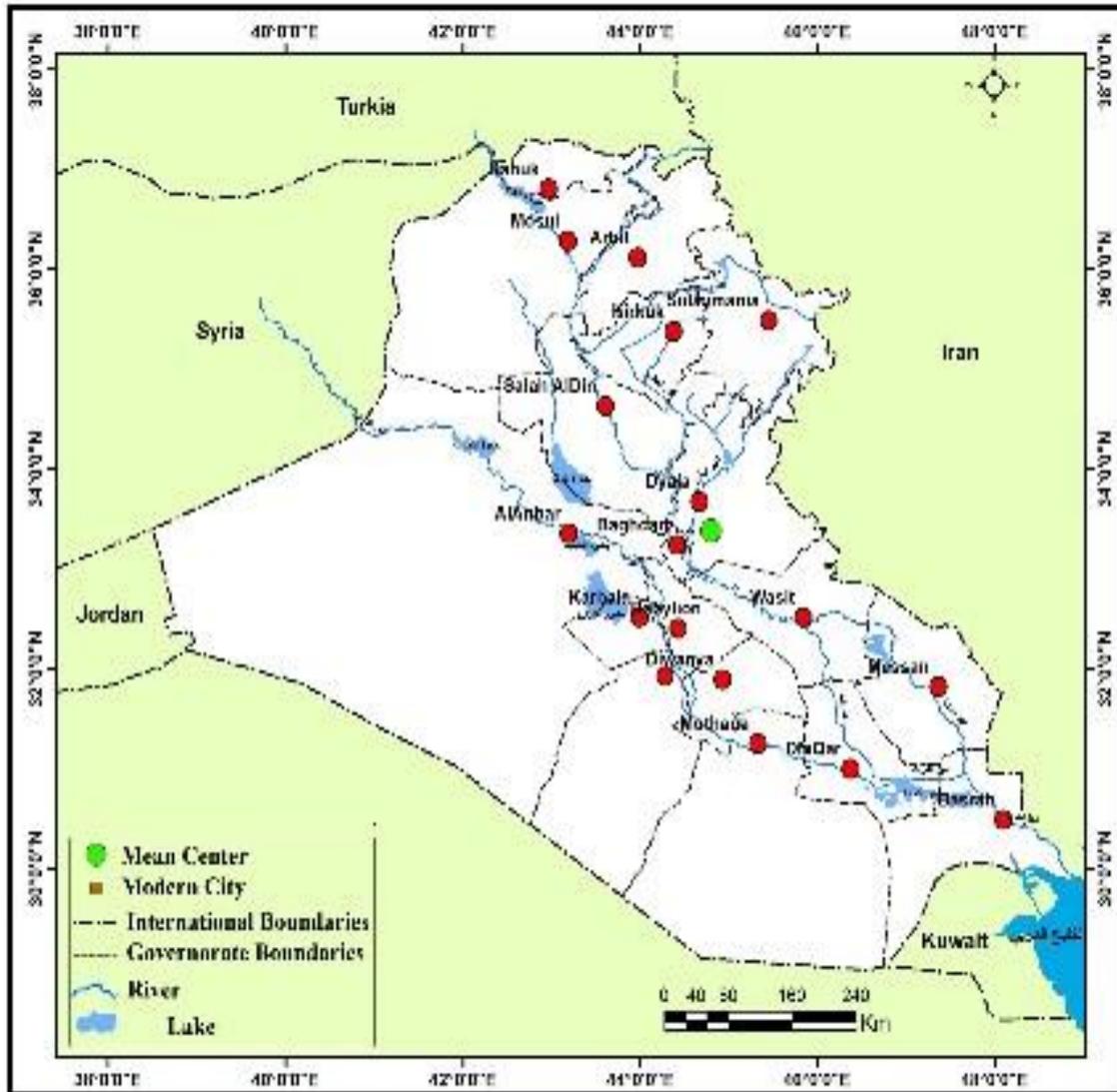
Source: Map created by the author, adapted from Al-Sabbani (2022), *Climate and Civilization in Mesopotamia: A Case Study* (p. 172).

Map (5): Spatial Mean of Iraqi Provincial Centers

"Map (5) compares the spatial mean (geometric center) of modern Iraq's provincial capitals, calculated using Geographic Information Systems (GIS), with the historical spatial planning of the Babylonian Empire. The spatial mean of modern Iraq's capitals is located

approximately 59 km northeast of Baghdad, reflecting a high degree of proximity between the calculated mean and the current capital. This precision is attributable to Iraq's compact territorial size compared to the expansive Babylonian Empire, which at its peak extended to the Levant and the Mediterranean coast (Al-Sabbani, 2022, p. 166). The analysis underscores advancements in modern spatial planning while contextualizing the challenges of managing larger, historically vast empires like Babylon."

Map (5): Spatial Mean of Modern Iraq’s Provincial Centers Using GIS



Source: Map created by the author, based on data from the Republic of Iraq, Ministry of Water Resources, General Authority for Survey (1995). [Geospatial data]. Baghdad, Iraq.

10. Nearest Neighbor Analysis of Babylonian Cities in Iraq

Nearest Neighbor Analysis (NNA) is a widely used method to interpret the spatial distribution pattern of point features by calculating distances, point counts, and study area extent. The output is an index ranging from 0 to 2.15. In this study, NNA was conducted using ArcMap 10.4 (a GIS software), employing the Average Nearest Neighbor (ANN) tool.

The ANN tool automates distribution pattern analysis based on critical values (z-scores). Input data included point features of Babylonian settlements. The tool calculates:

1. Observed Mean Distance

- 2. **Expected Mean Distance**
- 3. **Nearest Neighbor Index (NNI)**
- 4. **Z-score**
- 5. **P-value**

The z-score and p-value determine the statistical significance of rejecting the null hypothesis (random spatial distribution). For ANN, the null hypothesis posits that features are randomly distributed.

The Nearest Neighbor Index (NNI) is the ratio of the observed mean distance to the expected mean distance. Values <1 indicate clustering, >1 suggest dispersion, and ≈1 imply randomness. Distribution patterns are classified as:

- **Clustered**
- **Random**
- **Uniform**

(Sari et al., 2024).

For Babylonian cities in the study area, the ANN analysis revealed a random distribution pattern (Figure 1). Key metrics include:

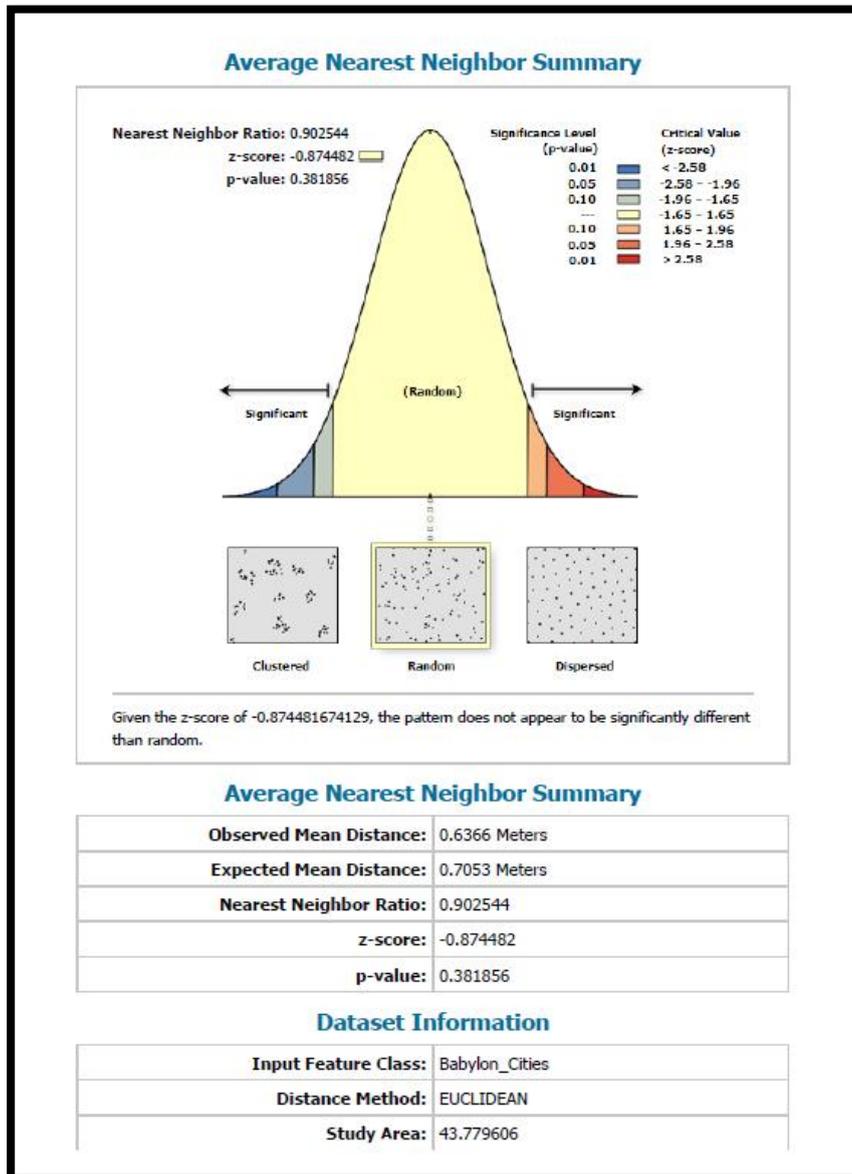
- **Nearest Neighbor Index (NNI): 0.902**
- **Number of cities: 21**

According to the standard critical value table (Figure 1), this NNI falls within the yellow-shaded zone, indicating

95% confidence that the cities are randomly distributed.

Figure 1: Visual representation of the Nearest Neighbor Analysis results for Babylonian cities. The yellow shading denotes the 95% confidence interval for random distribution.

Figure (1): Nearest Neighbor Index (NNI) Plot for Babylonian Cities in the Study Area



11. CONCLUSIONS

1. Variation in the Use of Geographic Coordinates Across Civilizations: The Babylonian civilization employed advanced quantitative geographic systems, surpassing the Sumerian and Assyrian civilizations in spatial planning sophistication.

2. Babylonian Precision in Geographic Coordinates: GIS analysis revealed that the Babylonians utilized precise mathematical methods for spatial organization, distinguishing their approach from contemporaneous

civilizations.

3. Strategic Spatial Mean of Babylon: The spatial mean of Babylonian capitals, calculated via GIS, closely aligns with the modern location of Babylon in central Iraq, with a displacement of ~150 km northeast. In contrast, the spatial means of southern (Ur: ~500 km) and northern (Ashur: ~750 km) capitals deviated significantly from their historical sites.

4. Random Distribution of Babylonian Cities: Nearest Neighbor Analysis (NNI = 0.9025) confirmed a random

spatial distribution of Babylonian cities, reflecting decentralized urban planning.

5. Capital-Centric Focus of the Babylonian Empire: The Babylonians prioritized precise siting of their capitals over systematic planning of subordinate cities.

6. Babylonian Proficiency in Spatial Analysis: The random distribution of cities underscores their advanced understanding of spatial mean calculations for capital placement.

7. Natural Geography in Sumerian and Assyrian Planning: Unlike the Babylonians, the Sumerians and Assyrians relied on environmental factors—river networks, fertile soils, and flat plains (southern Iraq)—rather than coordinate systems for capital site selection.

8. Environmental Determinants of Urbanization: Abundant water resources and arable land were pivotal in shaping the settlement patterns of Sumerian and Assyrian cities.

9. Evolution of Geographic Thought: The application of geographic coordinates in ancient Iraq marks an early scientific milestone, laying groundwork for later advancements in spatial analysis.

12. RECOMMENDATIONS:

1. Conduct Field Studies Using GIS and Geophysical Surveys: Implement advanced GIS technologies and geophysical surveys to reassess archaeological sites in Mesopotamia, enhancing accuracy in site evaluation and preservation planning.

2. Foster International Academic Collaboration: Launch joint scientific projects between Iraqi universities and global institutions to advance research in quantitative geography and spatial archaeology.

3. Train Iraqi Archaeological Teams in GIS and Remote Sensing: Develop specialized training programs to equip local archaeologists with cutting-edge GIS, remote sensing, and geospatial analysis skills.

4. Re-examine Archaeological Sites with Modern Technologies: Employ LiDAR, 3D modeling, and drone mapping to reinvestigate historical sites, uncovering new insights into ancient urban planning.

5. Promote Public Awareness of Iraq's Archaeological Heritage: Utilize documentaries, media campaigns, and educational programs to highlight Iraq's role as a cradle of human civilization.

6. Establish a Digital Database for Iraqi Archaeological Sites: Collaborate with academic institutions to create an open-access geospatial database documenting Iraq's cultural heritage.

7. Strengthen Governmental Preservation Efforts: Prioritize the protection and conservation of Iraq's

archaeological sites as pillars of the nation's cultural and creative identity.

8. Leverage Media to Spotlight Mesopotamia's Legacy: Encourage media outlets to emphasize Iraq's profound historical contributions to global intellectual and cultural development.

9. Develop Tourism Infrastructure Near Archaeological Sites: Build hotels, parks, and modern transportation networks to facilitate tourist access, fostering economic growth through cultural tourism.

Declarations

Conflict of interest declaration:

"The authors declare that they have no conflicts of interest related to this research."

Author contributions:

"[Faisal Kareem Hada AL-zamili and Aiman Adndn aboseaba] contributed to the study conception and design. The author critically reviewed and approved the final version of the manuscript."

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Availability of data and materials

"The data used in this research are available upon request from the corresponding author."

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