

Main Manuscript for

Mapping the Past: Geospatial Analysis as a Tool for Relative Dating the Mishnah and Tosefta

Key Words: | geospatial analysis | digital humanities | Jewish studies | textual dating |
historical geography

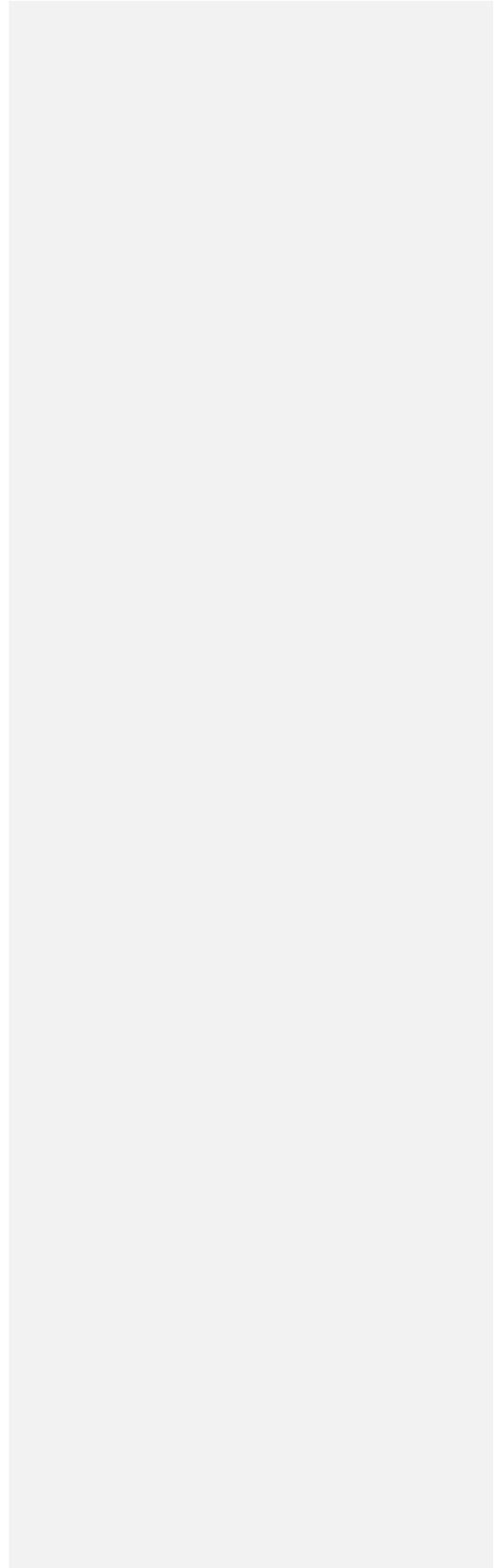
Abstract

During the late Roman period in the Near East (2nd-3rd centuries CE), two foundational Jewish texts emerged that would become cornerstones of Jewish legal tradition: the Mishnah and the Tosefta. These canonical works systematically codify the entire corpus of Rabbinic law, organizing their comprehensive legal discussions into thematic '*Sedarim*.' Their structured compilation preserved Jewish legal thought and established the textual framework that would shape Jewish legal discourse for generations to come.

The complex relationship between these two texts and their literary development has been a subject of scholarly debate for hundreds of years. Our innovative study breaks new ground by applying statistical and quantitative analytical methods to examine geographic data embedded in Rabbinic literature in order to ascertain the geographic context of the particular texts and their component parts and perhaps to shed light on where and when the Mishnah and Tosefta were compiled. This methodological approach not only enables a 'Sitz im Leben' analysis of these works but also contributes to understanding the spatial consciousness underlying both

texts and its connection to broader regional history. Our analysis of the data suggests that the Tosefta was redacted at a time when Jewish settlement in Galilee and peripheral areas was more developed and after the Judean highlands had ceased to be the sole center of Jewish intellectual activity.

The method used here can be applied to other fields and to both ancient and modern datasets. It offers a framework for applying geospatial statistics across a variety of historical contexts.



Significance Statement

Ancient texts preserve hidden geographic information that can reveal when and where they were written. By analyzing place names mentioned in two foundational Jewish legal texts using modern mapping and statistical techniques, we discovered distinct geographic patterns reflecting major historical changes in ancient Israel. The older text focuses on Judea, while the later text includes extensive references to northern regions, matching known population movements after a major revolt ended in 135 CE. This innovative approach—combining geographic information systems with statistical analysis—opens new possibilities for dating ancient documents and understanding how historical events shaped literary traditions. The methodology applies to texts from any culture or period, offering historians and archaeologists a powerful tool for reconstructing the past from written sources.

Main Text

Introduction

This study is the first attempt to use statistical and quantitative analytical methods to examine the geographic data found in the Mishnah and the Tosefta. This study uses statistical and quantitative analytical methods to examine the geographic data found in the Mishnah and the Tosefta. In the future, this data can help provide a “Sitz im Leben” analysis of these works. In this article, we use the data to show the geographic context of each work and its constituent parts. We suggest that additional investigation into the spatial picture may provide fresh perspectives on the editorial processes of the Mishnah and Tosefta, as well as new instruments for the study of their relationship.

The Mishnah and the Tosefta are the two most important Jewish legal compositions of the Tannaitic period (2nd-3rd centuries CE in the Land of Israel), and are in fact the only legal codices that we have from this period (1). The Tosefta, similar to the Mishnah in both form

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and content, is less central than the Mishnah in historical and legal importance. Still, the importance of the two texts in Jewish culture is immense: Alongside the Bible, these are the texts that have underpinned Jewish culture over the last 1800 years. More than the Bible, the Mishnah and Tosefta shaped the daily life of the Jewish community and served as a source for an ongoing exegesis, and were the focus of immense intellectual activity for a millennium and a half.

These two compositions cover the entire corpus of Rabbinic law. They are both divided into six thematic *Sedarim* (= sub-divisions, plural of *Seder*): *Zera'im* (agricultural laws), *Mo'ed* (laws pertaining to festivals and the calendar), *Nashim* (laws relating to the relations between men and women), *Nezikin* (civil law), *Kodashim* (ritual laws, mostly with regard to Temple rites), *Toharot* (laws relating to purity and impurity). The Mishnah became a canonical text of Jewish law.

The precise relationship between the Mishnah and Tosefta has been a topic of discussion for hundreds of years, beginning in the Middle Ages (2, 3), and scholars continue to disagree on the subject even today (4). Part of the difficulty in understanding the relationship between the two compositions stems from the fact that we have almost no explicit information about their milieu, their cultural or material world, or their redactors' motives for creating, collecting, and editing this literature.

The scattered geographical information found in these works presents us with the habitat of the sages whose discussions and debates are recorded, their imagined or real boundaries, and the concepts with which they analyzed the physical and cultural environment. Until recently, historical research has not yet made use of Geographic Information System (GIS) technology to investigate the spatial aspects of ancient literary works, nor have techniques of data analysis been used to determine the background of such works (The review by Barker et al.

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from 2024 (5)). David Bodenhamer (6, 7) has argued for the potential of deep mapping for spatial humanities. In recent decades, a number of monographs have addressed space-related concerns in the Greek and Roman world (8). The majority of the studies focus on the distribution of archaeological artifacts, the physical urban space, or the literary study of geographical components in ancient writings. Additionally, a number of GIS-based initiatives have created platforms for linking (LOD), access to a range of high-quality information, and the gathering and presentation of geographic data on digital maps for the study of space, history, anthropology, and sociology (5).

In spite of the field's remarkable progress and promising future, it appears that analysis of settlement patterns as reflected in ancient sources has not yet been undertaken. The implications of comprehensive statistical analysis of the data gathered for the study of ancient literature have not yet been fully realized. This is undoubtedly true to an even greater extent when studying late antique Jewish sources.

Until now, historical geography—particularly the identification of place names—has dominated studies of spatial awareness in Rabbinic literature. Yehudah Elitzur surveyed the geographic distribution of settlements appearing in the Palestinian Rabbinic composition *Leviticus Rabbah* (9). Liebner described the geographic distribution of settlements in *Ecclesiastes Rabbah*, another Palestinian Rabbinic corpus (10, 11). These efforts were founded on the great works from the preceding century, including those by Neubauer (12), Horovitz (13), Obermeyer (14), Klein (15, 16, 17), Segal (18), Eshel (19), Oppenheimer (20), Safrai (21). The most important work on geography in the Tosefta remains the geographical information included in Lieberman's commentary (22). Zussman's works (23, 24, 25) on the unique halakhic inscription from the Byzantine synagogue at Rehov are another valuable source for historical geography.

New historical, theoretical, and sociological conceptualizations of space in Rabbinic literature have recently been published by scholars such as Gil Klein (26) and Catherine Hezser (27). Using archaeological discoveries alongside Rabbinic texts, Liebner (28) has published an integrative description of Jewish settlement in the Galilee during the third and fourth centuries. Ancient Jewish texts have recently been statistically analyzed (29), but this is outside the time frame covered in this research.

This study focuses on the examination of space in ancient writings rather than the philosophy of spatial research, as per the classification of geographical research of ancient texts (5). We analyzed the toponymy of the settlements in the Mishnah and Tosefta across certain statistical and spatial factors. The Land of Israel (The Roman province *Syria-Palestina*) is the current study's primary emphasis, to the exclusion of the surrounding region. The two compositions are from the same era and are closely related in genre, the people mentioned in each, and the substantial laws and other elements discussed in them.

Results

The total number of place names in the examined corpus is 199. Places include names identified in the database as "city," "country," "village," "settlement," "well," "location," "region," "valley," "mountain," "stream," "river," "spring," "road." Since the names are ancient and most of the places no longer exist, it is very difficult to identify the place names, and we have therefore limited ourselves only to those place names that have been identified to a reasonable degree in the research done to date. Thus, from the total of place names, our analysis only includes places that are identified in the database as "city," "country," "village," and "settlement." The total number of such places in the Mishnah and Tosefta is 160.

The number of place names appearing in the various *Sedarim* of the Mishnah is as follows:

Zera'im 82, *Moed* 96, *Nashim* 70, *Nezikin* 53, *Kodashim* 69, *Toharot* 45.

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The numbers of place names appearing in the *Sedarim* of the Tosefta are:

Zera'im 171, *Moed* 158, *Nashim* 104, *Nezikin* 90, *Kodashim* 103, *Toharot* 101 (Fig. 1a).

The geographical analysis is based on those places with **unique names**. Unique place names for each text unit are as follows:

For the Mishnah:

Zera'im 27, *Moed* 29, *Nashim* 29, *Nezikin* 22, *Kodashim* 34, *Toharot* 21.

For the Tosefta:

Zera'im 27, *Moed* 48, *Nashim* 36, *Nezikin* 33, *Kodashim* 39, *Toharot* 47 (Fig. 1d).

Since the Mishnah and the Tosefta are of different lengths, the length of each composition (measured in words per text unit) should be taken into account when measuring the intensity of place-name mentions for purposes of comparison. The total number of words in the Mishnah is 188,628 (MS. Budapest, Kaufmann A 50), and the total number of words in the Tosefta is 304,097 (Ms. Wien, Österreichische Nationalbibliothek 46).

The ratio of unique places to the length of each work (number of words: GPW) for each *Seder* is as detailed in the table below (see Fig. 1b, table 1):

We measured the number of place names shared by the Mishnah and Tosefta. Though the texts are generally similar, only about 60% of the place names are in common (Fig. 1c). The map of shared places (Fig. 2) demonstrates the spread of places common to both works next to places that are unique to the Mishnah or the Tosefta.

The geographical spread is calculated using **convex hull analysis** (Fig. 1f).

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The Mishnah tractates had a mean convex hull area of 15,718.48 (SD = 5,339.50), while the corresponding Tosefta tractates had a mean area of 27,870.56 (SD = 12,267.55), across all six *Sedarim*. Although this represents the complete dataset and inferential statistics are not strictly necessary, a paired *t*-test was conducted for illustrative purposes. The difference was not statistically significant, $t(5) = -1.68$, $p = 0.153$. Five out of six Tosefta tractates exhibited a larger convex hull area than their Mishnah counterparts, with *Nashim* being the only exception. This suggests a general tendency toward a broader geographic spread in the Tosefta corpus. See Table 2.

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Using hierarchical clustering (Fig. 5), we identified three major groups of texts. One of these groups included five *Sedarim* from the Tosefta; two *Sedarim* of the Mishnah (*Zera'im* and *Moed*) are another group. The third group includes *Seder Nezikin* of the Tosefta and four *Sedarim* of the Mishnah: *Nashim*, *Kodashim*, *Nezikin*, and *Toharot*. The second group is well distinguished.

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Discussion

The Kernel Density Estimation (KDE) maps demonstrate that locations in the Tosefta are focused around two centers, one in Galilee and the other in the highlands around Jerusalem, Judea. All six Tosefta *Sedarim* contain elements of the Galilean center. The Mishnah maps present another model, including a main cluster in the highlands around Jerusalem and a less focused distribution of locations in the Galilee. The Mishnah *Seder* of *Nashim* is exceptional in that it has a more significant center in the Galilee, along with the main cluster in the Jerusalem highlands.

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The spatial distribution models of the Mishnah to the Tosefta differ in several ways:

1. The number of geographical centers: only one in Mishnah and two in the Tosefta.

2. The settlements mentioned in the Mishnah are concentrated in one area. In the Tosefta, there is more dispersal around the central hubs.
3. The Tosefta has a greater geographic focus on the Galilee than the Mishnah.

The *Seder of Nashim* is exceptional in that the Mishnah and Tosefta are more similar than in the other *Sedarim*. There are two clusters in both, with the southern cluster being larger than the northern cluster. The similarity of the Mishnah in the *Seder of Nashim* to the model in the Tosefta raises the question of the relationship between *Nashim* and the rest of the Mishnah regarding its relationship to the Tosefta.

The finding that the geographical arena reflected in the Mishnah is different from that in the Tosefta is significant. This difference exists despite the fact that the persons, era, language, literary style, and topics of both works are similar and often nearly identical. While the map of the Mishnah's locations includes places in the Galilee, the concentration of locations is far sparser than that of Galilee locations in the Tosefta. It is also clear that the locations in the Tosefta extend over a larger geographical area than those in the Mishnah, and can be found further from the center, particularly further from the center in the highlands in the Jerusalem region. Fig. 3 also highlights the variation between the Mishnah and the Tosefta against their general similarity. Examining all the points in both works together reveals that both focus on similar geographical areas (Galilee and Judea). It is noteworthy that relatively few locations are shared by both works.

Another noteworthy finding is that the central Galilean clusters in the Tosefta extend eastward to Transjordan. In the Mishnah, only a few places located east of the Jordan River appear.

The relative absence of places in Samaria on the maps of both the Mishnah and the Tosefta is another significant observation. According to the accepted view in historical scholarship, up

to the second century CE, this region was heavily populated by a variety of populations, including Samaritans, but by relatively few Rabbinic Jews. Accordingly, the relative absence of places mentioned in this region is not surprising.

We propose a historical interpretation of the data presented here based on the demographic developments in the Land of Israel following the Bar Kokhba revolt (suppressed in the year 135 CE), in which Judea was devastated. During the second and third centuries CE, the main body of Jewish settlement moved to the Galilee. During this time, the central institution of the sages of the Mishnah and Tosefta, the Sanhedrin, also moved to the Galilee, or at least, that was the later sages' narrative about the shift from Judea to Galilee (28). We propose to date certain parts of the Tosefta to a later period than the corresponding parts of the Mishnah based on the picture of a more developed Galileean settlement in the Tosefta.

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We suggest that portions of the Tosefta (besides *Nashim*) were composed or edited in a different geographical area than the Mishnah. The prevailing view is that the final editing of the Mishnah took place at least 150 years after the destruction of the Temple (in 70 CE) and, consequently, that the quantity of early sources preserved in the Mishnah is minimal. In contrast, we point out that the dominant geographical cluster in the Mishnah in most of its *Sedarim* is in the area of Judea, and the proposed maps of the Mishnah reflect the picture of the Jewish settlement before the Bar Kokhba revolt.

Irrespective of the question of dating, the Tosefta maps support the idea that the Tosefta drew upon Tannaic material that originated in a wider geographical (and social) circle than the Mishnah. The Mishnah appears to have mostly drawn upon material from the sociological and intellectual center, as is reflected in the maps tracing the locations mentioned in the Mishnah. Based on this information, we suggest that the Mishnah preserves mainly Judean

literary traditions while the Tosefta includes other literary traditions, which originated in the Galilee or other formerly peripheral Jewish settlements, and dates to a later period.

With regard to the dating of the texts, our dataset indicates that the Tosefta was developed and redacted at a time when there was significant Jewish settlement in places besides the Judean highlands and surrounding areas, particularly the Galilee.

Future Research:

Further study is planned based on the data presented here. We hypothesize that the Tosefta mentions cities more extensively than the Mishnah. If that turns out to be the case, one may conclude that the Tosefta was influenced by the urbanization process that took place during the Severan dynasty in the late second and early third centuries.

Materials and Methods

Radar chart (Fig. 1):

In this analysis, we compared the geographic references in the Mishnah and Tosefta across the different *Sedarim* using various metrics. First, specific and generalized place types (e.g., city, village, mountain, etc.) were filtered from the dataset to create two subsets for analysis. These subsets were used to calculate ratios of specific to generalized places and standardize counts of references to account for textual word count variations.

We standardized the data to ensure fair comparisons between the Mishnah and Tosefta across different *Sedarim*. Reference counts were normalized by dividing them by the total word count of each source, thus accounting for the differences in textual size. Unique places were also standardized relative to the total references, highlighting proportional diversity in geographic mentions. Geographic dispersion was quantified by calculating bounding box

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areas, with outliers removed using the interquartile range (IQR) method, and areas were converted to square kilometers.

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The intersection of places mentioned in both the Mishnah and Tosefta was measured as a percentage to highlight shared locations. Results were visualized through radar charts to compare metrics such as reference counts (Fig. 1a), normalized references (Fig. 1b), unique place counts (Fig. 1d), normalized unique places (Fig. 1e), and geographic spread (Fig. 1f). A bar chart was also added to show the percentage of shared places between the Mishnah and Tosefta for each *Seder* (Fig. 1c). The visualizations provide an overview of the geographic context of both works, providing new insights into the differences and similarities between the two sources. However, for the purpose of a spatial and statistical analysis, we isolated the geographical component and assigned each name a single place value in each work, regardless of the number of times it recurs.

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Common Places Analysis

This study examines the geographic references in the Mishnah and Tosefta, identifying shared and unique locations and visualizing them on a map. Unique place references were filtered by removing duplicates based on `place_id` (a database identification number for each place name), and the data was divided into three categories: locations shared by both sources, locations unique to the Mishnah, and locations unique to the Tosefta. Latitude and longitude coordinates were converted into spatial points using `GeoDataFrames`, enabling geographic plotting. A base map from Esri's "World Gray Canvas" was used to provide geographic context, and the shared locations were marked in green, the Mishnah-only locations in red, and the Tosefta-only locations in blue. The map highlights patterns of overlap and divergence between the two sources, offering insights into their distinct and common geographic focuses.

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Kernel Density Estimation: (maps)

We generated KDE maps to visualize the geographic distribution of references in the Mishnah and Tosefta across the six *Sedarim* (Fig. 3 and Fig. 4). For each combination of source (Mishnah, Tosefta) and *Seder*, we filtered the data to include only valid geographic coordinates within a defined bounding box. KDE was applied to these coordinates to estimate density, and the top 10% of density values were highlighted using filled contour plots. Contour lines were added for clarity, and the original reference points were overlaid on a base map for geographic context. The results were displayed in a grid of 12 subplots, with rows corresponding to the sources and columns to the *Sedarim*, providing a comprehensive comparison of the spatial patterns between the Mishnah and Tosefta.

In this study, we utilized hierarchical clustering to analyze the distribution of locations in the six *Sedarim* of the Mishnah and Tosefta based on a combination of geographic and textual features (Fig. 5). The geographic features included the central point of locations (mean latitude and longitude), the average distance from this central point, and cluster statistics such as the number of clusters and average points per cluster derived using DBSCAN. We also incorporated density-based features calculated via KDE, such as peak density, mean density, standard deviation of density, and density at the central point. Outliers in geographic coordinates were removed using IQR filtering to ensure robust calculations. The extracted features were standardized and used to construct a dendrogram using Ward's linkage method. Leaf nodes in the dendrogram were color-coded by source (Mishnah or Tosefta) to distinguish patterns and relationships across sources visually. This approach provides a detailed, multidimensional understanding of the clustering structure of the *Sedarim*.

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Figures and Tables

Figure 1

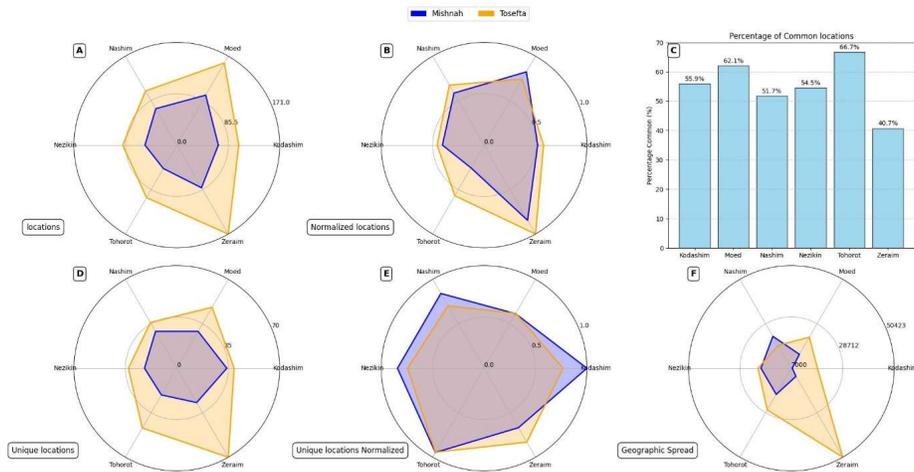


Figure 1a: Number of locations in the Tosefta vs. Mishnah.

This graph shows that the number of locations mentioned in the Tosefta is significantly greater than those mentioned in the Mishnah.

Figure 1b: Number of locations in the Tosefta vs. Mishnah, normalized.

The number of geographic references is calculated relative to the total number of words in each composition (GNW: Geographic Names per Word). When normalized in this way, the relative number of geographical references in the Mishnah is much closer to that in the Tosefta, and, in the case of the *Seder of Moed*, the Mishnah contains relatively more geographical references than the Tosefta. In the other *Sedarim*, the Tosefta contains relatively more geographical references than the Mishnah. In *Nashim*, *Nezikin*, and *Kodashim*, the

relative difference in the occurrence of place names is small, while it is more meaningful in *Zera'im* and *Toharot*.

Figure 1c: Percentage of locations appearing in both works.

About half the places appear in both works. The degree of common place names varies significantly across the *Sedarim*.

Figure 1d: Number of locations appearing uniquely in the Tosefta vs. Mishnah.

Figure 1e: Number of locations appearing uniquely in the Tosefta vs. Mishnah, normalized.

Figure 1f: Geographic dispersion of location names.

This graph presents the distance between the most distant places mentioned in the Mishnah vs. the Tosefta, from other points in the same work. The Tosefta includes more peripheral place names than the Mishna, in most *Sedarim*, excluding *Seder Nashim*.

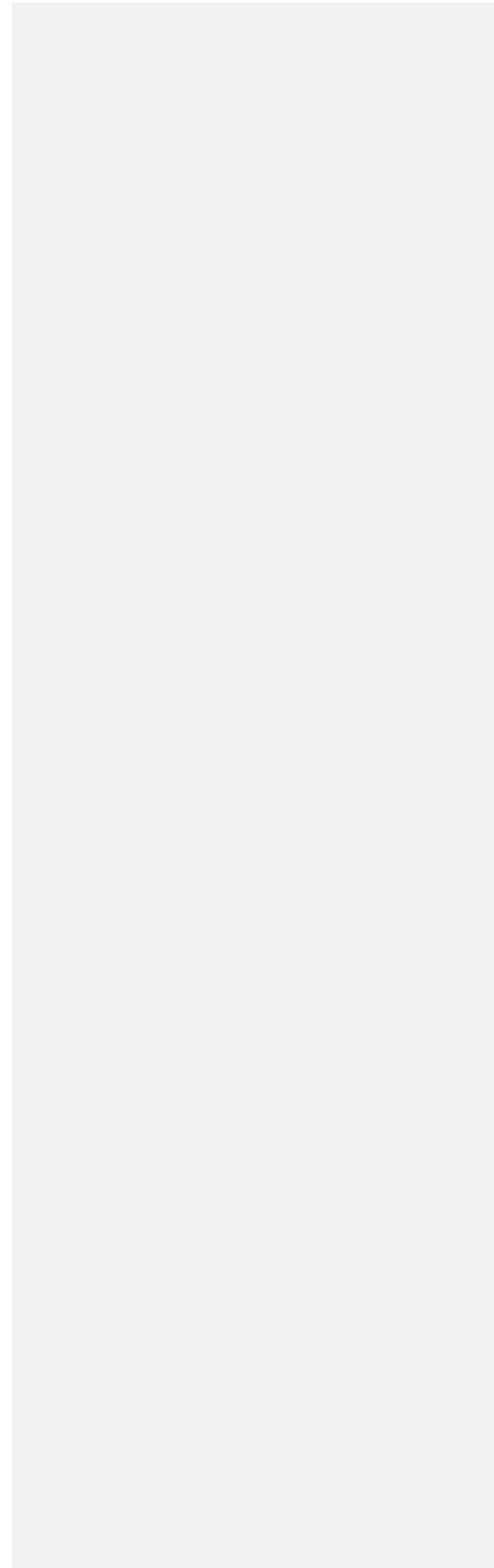


Figure 2

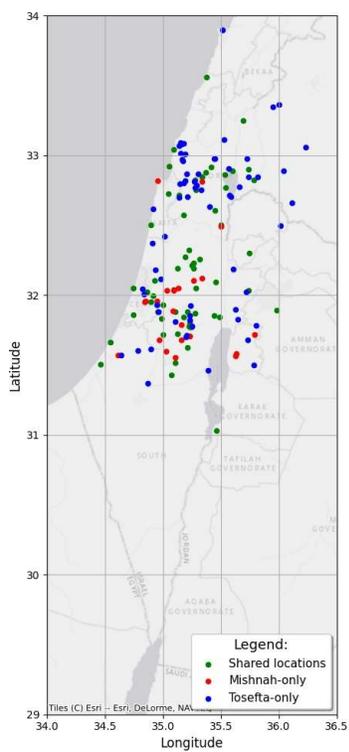


Figure 2: Geographic distribution of place names in the Mishnah and the Tosefta.

Locations in green are found in both. Locations in red are exclusively found in the Mishnah. Locations in blue are exclusively found in the Tosefta. The distribution of the places common to both works is even, with no exceptional pattern being identified.

Figure 3

KDE Density Maps for Mishnah and Tosefta by Seder

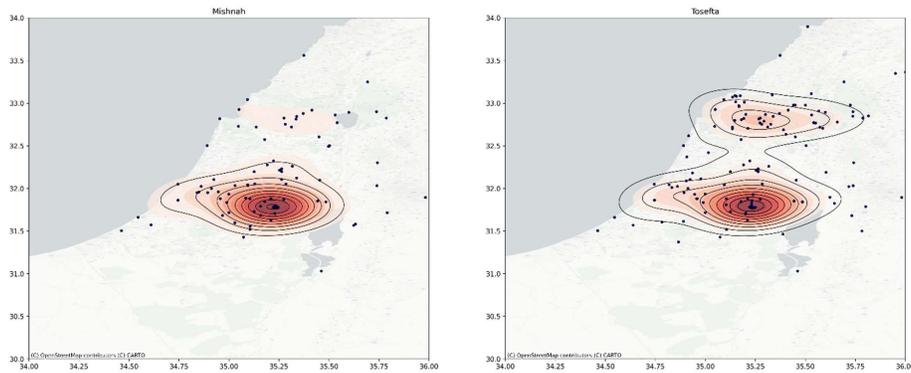


Figure 3: KDE of place names in the Mishnah vs. the Tosefta.

KDE maps compare the dispersion of place names; each place name is marked once only, regardless of the number of times it is mentioned in each composition. Fig. 3 shows that both compilations contain place names in a significant cluster in the central highlands near Jerusalem and extending west toward the Judean foothills and the coastal plain. However, the Tosefta also had another significant cluster in the middle of the Lower Galilee. Other locations are dispersed or in very small clusters around the two main clusters.

Figure 4

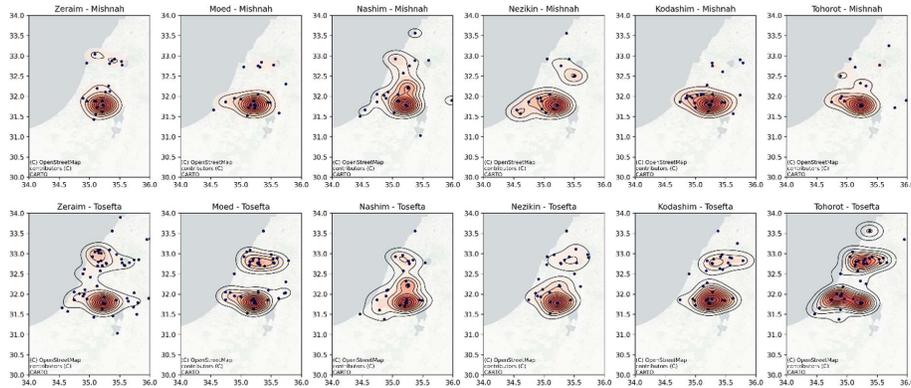


Figure 4: Mishnah (upper row) and Tosefta (bottom row) maps of settlements' distribution (unique place names), divided by Sedarim.

The locations mentioned in the Mishnah are concentrated in the Judea highlands around Jerusalem and extend westward, while there is a relative paucity of locations in Galilee. The only exceptional *Seder* in that sense in the Mishnah is *Nashim*, which presents a meaningful cluster also in the Lower Galilee.

Figure 5

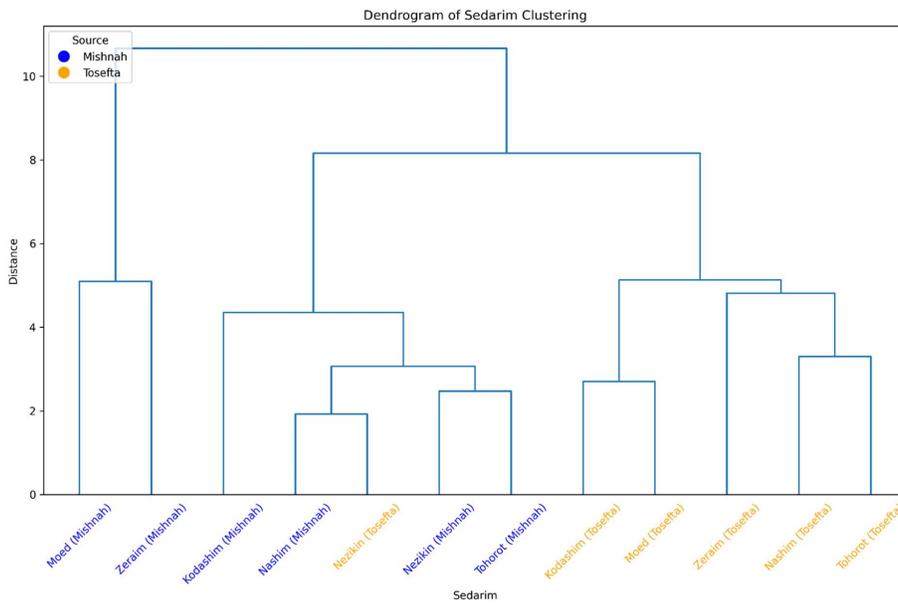


Figure 5: Clustering of spatial features (dendrogram)

Table 1

Seder	Mishnah	Tosefta
Kodashim	0.492753623	0.378640777
Moed	0.302083333	0.303797468
Nashim	0.414285714	0.346153846
Nezikin	0.41509434	0.366666667
Toharot	0.466666667	0.465346535
Zera'im	0.329268293	0.409356725

Table 1: Unique Places Normalized per Word, for each Text Unit

Table 2

Geographic Spread by <i>Seder</i>	Mishnah	Tosefta
<i>Kodashim</i>	7396.475557	18033.83339
<i>Moed</i>	13808.46869	22173.23098
<i>Nashim</i>	22579.03879	18157.00805
<i>Nezikin</i>	19816.26996	21096.68665
<i>Toharot</i>	19771.43603	27316.64418
<i>Zera'im</i>	10938.20467	50442.94051

Table 2: Convex hull for Mishnah vs. Tosefta, by *Seder*

