Quantitative variable point analysis:
Methodological underpinnings of affordance exploration and how to address distances meaningfully

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Abstract

This compendium presents the procedure and conceptual underpinnings associated with the developed method of site location analysis of selected variables through delimited point grids, tested on 30 settlement sites dating to the Late Neolithic and the Bronze Age (2350-500 BCE) in southeast Norway. For the theoretical underpinnings, presentation and discussion of the results see the original peer-reviewed paper (Sand-Eriksen 2023). The main findings of the analysis demonstrates that method is suited to address conditions that made LN/BA people settle down, and through it get a more nuanced understanding of the environments in which past people lived their life's and how such land-use patterns changed over time. I see the method especially relevant for those that want to address distances in detail. The compendium also contains some elaborations on data selections, including sources and accessibility of the analysed variables, but also highlights some potential improvement of the method and associated approaches.

Keywords: affordance, GIS, variable point analysis, correspondence analysis, meaningful distance

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1 Introduction

This compendium presents the procedure and conceptual underpinnings associated with the developed method of site location analysis of selected variables through delimited point grids using geographical information systems (GIS). The method was developed to assess the relations between settlement sites and mapped variables (source data) through point analysis distribution within delimited point grids. Within geographically limited study areas, or windows of existence, this compendium follows a peer reviewed paper by the author (Sand-Eriksen 2023) which explores the correlations between longhouse settlement site locations from southeast Norway dating to the Late Neolithic (c. 2350-1700 BCE) and Bronze Age (c. 1700-500 BCE) and 12 selected variables, of both natural and cultural character. The aim of the main paper was to provide a better understanding of how people weighted up various landscape factors when deciding where to settle down in prehistory, and help approach how site locations, here focusing on settlements, can improve our understating of past human-environmental engagements through applying the concept of affordance (Gibson 1979).

In the following compendium, I also include information on the main treatment and robustness of the data through the method of correspondence analysis and statistical evaluation of data. The focus is, however, on the developed method, as for others to adopt and adapt if wanted, including an elaborations on the data selection and choices made during the development of the method.

2 Data selection

2.1 Settlement sites

The 30 selected settlement sites (see main paper for details, Table 1 holds information on names) are part of a larger dataset consisting of 145 buildings from 56 sites, collected by the author from reviewing excavation reports from the Museum of Cultural History (MCH). The sites were selected based on spatial and temporal representativity within southeast Norway and the Late Neolithic and Bronze Age, where the most well-dated houses were chosen in combination with the following scaling system established of the definability of the houses:

1) Houses with definable ground plan can be either a) complete, meaning that both roof-supporting and wall posts are preserved, preferably also gable walls; or b) incomplete, meaning that certain elements are lacking, but without it compromising how definable the buildings are.

2) Houses with partly definable ground plan can consist of either a) secure structural elements, such as a line of roof-supporting posts, preferably in combination with partial structural elements, such as an entrance or a partial wall, the building measurements are incomplete, but type and/or form are likely; or b) partial structural elements, such as a gable wall in combination with one roof-supporting post, the building measurements, type and/or form are tentative.

3) Houses with undefinable ground plan can consists of either a) clusters of post holes that cannot be put into any order; b) too few post holes to decide an order.

Although the best suitable sites were chosen according to the scales, a site scaled low based on how definable the house were can be chosen ahead of one that is scaled higher if that site is situated in an area with few or no other houses or is dated to a period with few or no other houses.

2.2 Analysed area

To be able to create an as detailed picture as possible, but keep within the scope of the study, I decided to set the geographical area to 5 km from all sides of the site. Subsequently creating a zone with a diameter of 10 km. Research historically, there are several different sizes used when exploring ‘catchment areas’ or ‘exploitation territories’ surrounding settlement sites. A distance of 5-10 km results in a 1-2 hour walking distance from the site (Higgs and Vita-Finiz 1972; Vita-Finzi 1978; Vita-Finiz and Higgs 1970), and is argued to be most suitable when studying the LN and BA in southeast Norway (Østmo, 1988, 133-134). The zone can, however, be scaled up and down, all depending on the wanted or required for other studies.

2.3 Cultural variables

In addition to reviewing literature and excavation reports (available by searching site name at duo.uio.no, community ‘Museene’ and then ‘Kulturhistorisk museum’), data on cultural variables have been retrieved from the Norwegian museum's database Unimus/Musit (partly accessible from unimus.no) and The Directorate for Cultural Heritage's database Askeladden (askeladden.ra.no). These are archaeological databases which are semi-open, belonging to Norwegian cultural resource management (CRM), but were you can ask for permission of insight. For Askeladden, for instance, certain information will be lacking for persons not employed within the heritage management sector/s, such as details related to casework and/or dealings with cases, finds, and excavations. Much of the same information is publicly available at the open-access site kulturminnesok.no, also provided by the Directorate for Cultural Heritage.

2.3.1 Grave context and rock art

I used Askeladden for data on variables grave context ('gravminne'and 'gravfelt') and rock art ('helleristninger'), which can be exported from Askeladden as shapefiles. Available data on grave contexts from Askeladden are often roughly placed within wide raging timeframes. Those placed within 'Bronze Age-Iron Age' have been omitted unless additional information can support a more precise date (e.g., typological finds or surveys). Therefore, I want to stress the insecurity of this data. Since most of the data is generally placed within 'Bronze Age' this data were applied to all sites but those dated to the LN only. If the grave context were narrowed down, e.g., to 'Early Bronze Age', the variable was only attributed to sites with corresponding or later dates (reason on the latter is accounted for in article). Apart from taking this information into account when applying the data to the individual sites, the data from the shapefiles were not altered in any way. Likewise with the data on rock art, but this was attributed to all sites alike. Although there are possibilities of finer chronologies in rock art, for example associated with ships (e.g., Ling, 2008), this would have required a tremendous workload which and I decided to not take single motifs into consideration.

2.3.2 Other sites

Information on other sites is derived from a dataset of over 2000 radiocarbon dates from c. 600 sites across southeast Norway, initially established by Kjetil Loftsgarden and Steinar Solheim at MCH. I have cleaned their database and provided extensive additional information through detailed revisions of excavation reports in duo.uio.no. Most of these sites have Askeladden IDs, meaning that exact locations are retrievable as shapefiles. Sites that do not have IDs have been manually georeference after data on maps and information in the excavation reports.

2.3.3 Finds

While some of the finds, and then particularly bronzes, are rather newly added to the Unimus database do to increasing metal-detecting, and hence have rather precise information regarding find spots, many of the artefacts in the database have sources dating back to the 19th and early to mid-20th century. Unfortunately, several of these artefacts have arbitrary or imprecise locations. In addition to finds with information on coordinates, such as metal-detecting finds, only artefacts that could be securely attributed to a named farmstead and fairly precise location within it were included in the analysis. This means that most of the finds do not provide automatically georeferenced data, such as grave contexts and the rock art, and therefore done manually for each individual find. Albeit time consuming, and something of course can lead to some discrepancy according to exact find location and placed location, it assures in-depth knowledge about the finds prior to the analysis. As the georeferencing were done while the 5 km zones and point grid were established, finds topologically dated to the LBA can be omitted from a site radiocarbon dated to the EBA even prior to the analysis. Furthermore, I also used this step to reassure that these point features corresponded with on of the points from the grid, if not the points where buffered as for it to be read by the closest point- to not loose any information. Since the point grid lag is set to 250 m (see below), ant uncertainty between referenced finds and their exact find location would likely not surpass this lag, and hence not have any effect on the robustness of the analysis or the results.

There are always uncertainties in areal representativity of cultural data. Mounds can, for example, have been lost or destroyed due to ploughing. Therefore, loose or stray finds, which often are handed in from cultivated field, can in fact represent grave mounds. Since these finds make up a rather small category of data, which I have added as a separate finds list in repository, I have revised it to look for such mounds. Of these finds, there are several that could represent burials based on it being so-called high status objects or objects that are often associated with grave goods (e.g., razor, tweezer, sword, belt plate), albeit it is only one single find that is within 1 km from the site. This does not change the overall result of the study. In addition to the high status objects, I also looking into the sites with many finds, and particularly to look for typologically concurrent finds to reveal grave assemblages. Due to the point IDs, relation in closeness of them could easily be taken into consideration, but I could not successfully pair any together as grave goods, but they could in fact perhaps be 'other sites' and mainly short term or economic visits. Suitable cases can also be viewed alongside absent of grave context. One stand out case is Holstad, which also has rather many finds, but this site was actually encountered in the outfield (Winther 2021),in an areas which had not been ploughed. Moreover, the finds from Holstad are mainly found in the outer part of the zone. With the exception of Arctander, where a spearhead (C22609, information available at unimus.no/portal searching for provided number) where found within 1 km from the site, no obvious burials were encountered.

2.4 Natural variables

The source data for the natural variables are freely available mapped datasets retrieved from the Norwegian Mapping Authority, with source data belonging to different research institutes in Norway. This data is under the Norwegian Licence for Open Government Data (NLOD) 2.0, for detailed information see https://data.norge.no/nlod/en/2.0.

I have used N50 data, which means that they are Norwegian medium-resolution land resource dataset in scale 1:50.000, with a minimum mapping unit of 1.5 hectares. While N5 data exist for some of the variables, such as NIBO data (see below), it is not open access but has limited availability that must be applied for. For relevant data, the main difference between N5 and N50 is on quality above present day forest line (Heggem et al. 2019), which is not relevant here.

2.4.1 Sea

The exception is the variable sea, which has no downloadable source data. To derive data, I set digital elevation models (DEM) according to the corresponding shoreline displacement. This vary along the coastline, with the relative sea-level being c. 20 m higher in the LN on both sides of the Oslo Fjord (Sørensen 2002; Sørensen et al. 2014. Towards the west and the southernmost parts of the study area in Agder the displacement have been less dramatic, about 4 m in the LN (Prøsch-Danielsen 1997; Romundset et al. 2014). Information on relative shore according to these sources were taken into account and adjusted on site level, so that each site were analysed based on contemporary sea-level.

2.4.2 Freshwater

The Norwegian Water Resources and Energy Directorate (NVE) were used for freshwater resources such as rivers and lakes . I used AR50 dataset with 'Elver' (small rivers omitted) and 'Innsjøer' (the data is available at http://nedlasting.nve.no/gis/, see also atlas.nve.no). I found 250 m lag sufficient to not ignore linear features such as rivers, but I also checked correspondence with overlay grid before doing the reading. As with point data from the cultural variables, this was buffered to nearest point if needed.

2.4.3 Wetland

The Norwegian Institute of Bioeconomy Research (NIBIO) were used for data on wetland, I used AR50 dataset filtering 'myr' (available at https://kart8.nibio.no/nedlasting/dashboard). While I analysed these as wetlands, what is wetland today do not necessarily have to have been wetlands in the Bronze Age, as they could have been lakes. As wetlands and bogs take time to form, however, I decided to not included this within the freshwater category, as it also could reflect small lakes starting to become wetlands. These would have afforded also very distinct animal, fungal, and plant species assemblages compared to freshwater sources.

2.4.4 Forest

NIBIO were used for forest (i.e., soils based on forest quality of yielding capacity), with same dataset as above only filtering 'skogsbonitet'. This could be further filtered from high to none, omitting the latter from the analysis. The N50 data for forest is generalised from the N5 dataset (Heggem et al., 2019, 14). While this variable measures forest yielding capacity, this again rely on soil and bedrock conditions.

2.4.5 Clay

For data on clay, I used the The Geological Survey of Norway (NGU) dataset on loose soil sediments (Løsmasser, N50) further filtered into in the various clay deposits and sediments (available at https://www.ngu.no/
geologiske-kart/datasett).

2.4.6 Terminal moraine

The same NGU dataset loose soil sediments further filter after moraines were used to map terminal moraine deposits. This variable were included as such deposits are nutritional soil, suitable for agriculture. It has been hypothesised (e.g., Østmo, 1988, 1991) in Norwegian archaeology that this was the largest terminal moraine Raet were preferred for establishing farming in the LN and that the position of settlements either inside or outside of Raet changes over time.

2.4.7 Dry grazing landscapes

The variable dry grazing landscape have combined sources, including NIBIO's grazing map (Beitebruk) filtered at 'beitemark' (available at https://kart8.nibio.no/nedlasting/dashboard) and cultural landscapes from The Norwegian Environment Agency filtered to relevant types (available at https://karteksport.
miljodirektoratet.no/)

2.4.8 Suitable agricultural soil

NIBIO dataset AR50 filtered at soils suitable for agriculture (dyrkbar jord) and 'jordkvalitet' were used. The latter has three classes from high to low sutiability. Classes 1 and 2 were included, while class 3 was omitted, which consist of soil regarded to be less suited due to its slope of 33 % or more (both available at https://kart8.nibio.no/nedlasting/dashboard).

3 Methodological approach of variable point grid analysis

To acquire information on the variables from the source data, a point grid was created inside the 5 km areas surrounding the settlement site, with the point lag set to 250-meter. The zone and the point lags can be scaled up and down, all depending on the wanted or required mesh of other studies.

3.1 Setting up the point grid

In QGIS, the size of the zone is set using the 'Geoprocessing tool' under Vector. Then chose 'Buffer' and wanted site for analysis as input layer, and the wanted size of buffer zone. Now a grid can be created around the zone using the 'Research tool, with the grid extent equal to the buffered zone. Here the point lag can be decided. During the test analysis, I experimented with both finer and coarser meshes, but found that 250 m lag provided the most suitable level of details for the aim of this study (site locations) without smaller variable occurrences falling through. The grid comes out a square, for visual purposes the points outside the zone can be deleted. With 5 km zone and lag of 250 m, this will result of a mesh of 1201 unique points within each grid.

3.2 Reading and clipping the source data

Since there are 12 variables, there could be as many as 14 412 data observations within each single site. To attain this information, the points need to read the source data by using the geoprocessing tool and now 'Clip'. While this can depend on the source data, I chose to change it to polygon data by replicating the source information as a new layer within the 5 km zone (as exemplified in Figure 1), which also allowed me to double check that no information was left behind in between any of the points, such as linear features or even small variable data such as a lake or a bog, and of course the cultural variables. After the variable layer is prepared, it can be set as overlay layer and the grid as input layer, which now will be clipped according to the variable presence. To ease the process, this can be done by clipping the source data to the zone, and use that as point of departure. In my experience, however, this was less reliable than the creating polygons, albeit much quicker. If the latter is chosen, it is important to check

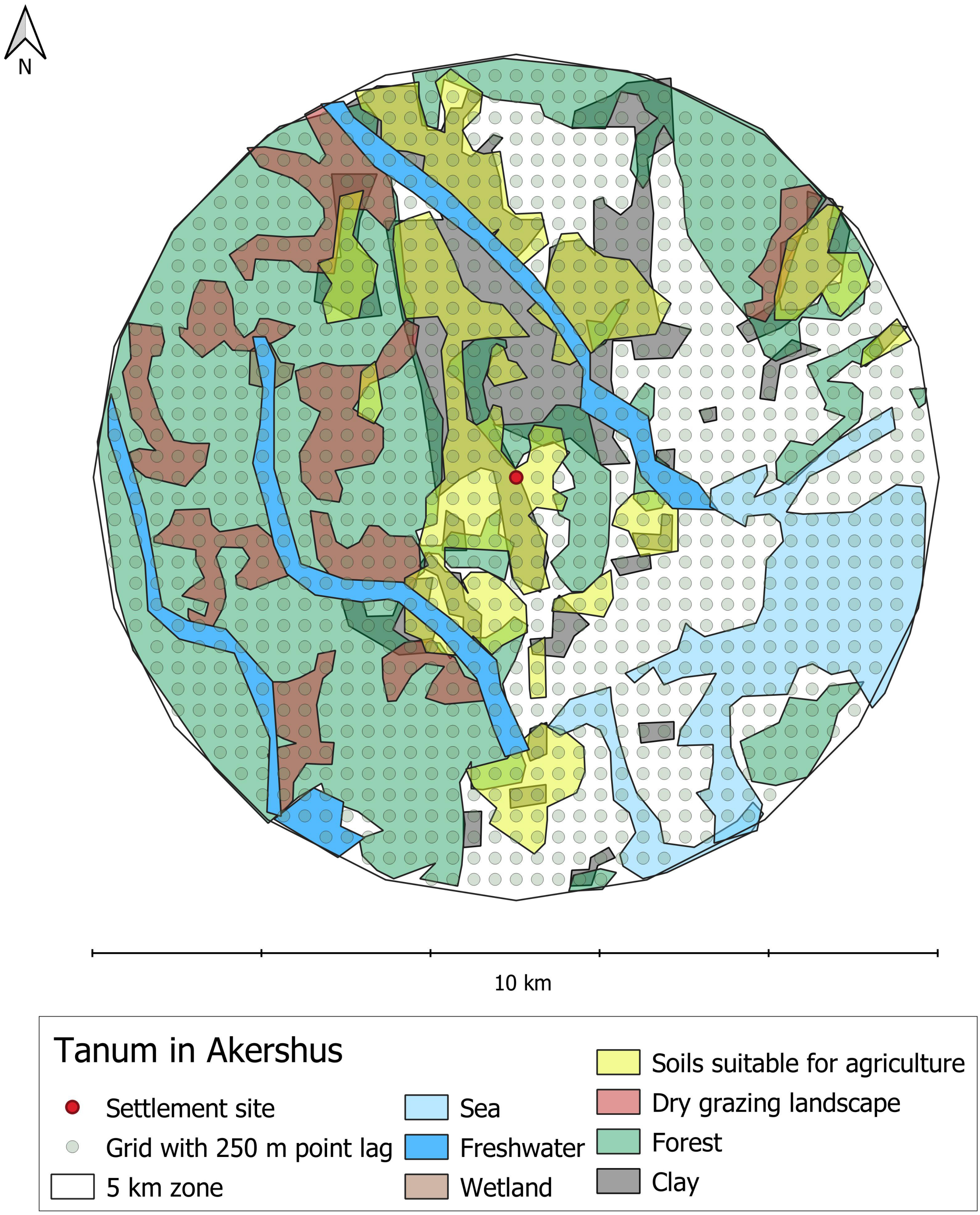

Figure 1: Example of analysis process. To demonstrate how the points while read data from corresponding (input) source layers I here present polygon layers of the natural variables, visually demonstrating how one point can read data from several variables. The point grid is then clipped after variables, and exported as tables (map by author).

that features which are originally filtered away are not included, e.g., such as I chose to filter away 'class 3' of soil quality, as this reflect soils that is less suited for agriculture.

3.3 From attribute tables to underlying dataset

The point grid was clipped according to each of the variable layers, resulting in an individual attribute table of the referenced points that overlaps with the variable input data. When this process is completed for all variables within one site, the 12 tables were exported from QGIS and unified using Access. The same process was then preformed on all 30 sites.The number of points within each site depends solely on the presence or absence of variables, some are frequently counted – such as the variable forest – while others are not present within the grid at all or generally more scarcely encountered, such as the four cultural variables. This results in individual point counts and variables assemblages for the sites (sum Table 1). Lastly, the 30 individual tables were combined to one underlying dataset of 48,130 individual observations for further analysis and visualization. These observations are summarised in the below contingency table (Table 1).

	Variables												
Site	1	2	3	4	5	6	7	8	9	10	11	12	Sum
Arctander	231	64	14	448	26	0	85	312	11	54	19	3	1267
Romsletta	74	96	18	960	29	0	112	6	2	0	1	2	1301
Homme	207	131	4	856	3	0	13	142	7	1	1	5	1226
Klepland	172	135	5	817	106	0	0	142	7	1	2	5	1391
Moi	0	128	22	905	124	0	0	0	0	0	0	0	1179
Larønningen	117	69	7	514	595	0	46	221	2	14	1	4	1590
Eidsten	570	55	16	338	75	91	17	239	0	8	6	1	1416
Nordby	68	148	59	554	263	63	38	244	0	2	8	16	1463
Løveskogen	334	56	46	427	118	27	6	234	2	4	18	5	1277
Heimdal	299	164	9	276	332	58	2	271	5	9	7	6	1438
Rør	205	149	4	341	419	88	8	410	4	21	8	7	1664
Borge	179	121	8	563	317	49	0	287	5	45	3	6	2584
Kjenne	192	7	0	579	69	12	19	312	11	80	4	4	1289
Glemmen	258	25	4	510	276	8	8	272	10	56	4	4	1435
Opstad	184	88	2	378	437	104	0	321	15	72	2	9	1612
Grimstad	334	2	0	461	345	6	13	299	18	92	6	4	1580
Stensrød	391	4	10	634	95	3	10	84	6	2	10	0	1249
Øberg	202	68	0	565	389	45	16	212	1	6	2	3	1509
Rudskogen	0	5	32	837	246	0	33	277	1	0	2	0	2433
Østereng	0	29	3	572	74	0	61	486	0	2	0	1	1228
Nordre Moer	0	77	0	445	950	75	126	658	0	5	5	3	2344
Holstad	11	82	3	423	911	125	57	614	1	14	8	13	2262
Løken	0	64	17	656	632	0	81	480	0	0	0	1	1931
Tanum	104	74	3	602	247	39	133	206	0	10	3	4	1325
Huseby	0	40	23	446	924	0	43	568	1	0	1	4	2050
Asak	0	54	4	526	761	0	102	554	0	0	1	5	2007
Svarstad	0	28	6	593	656	0	64	615	0	2	1	0	1965
Haug	0	41	7	626	480	0	163	393	0	0	5	7	1722
Rudsøgård	0	389	16	626	31	0	36	222	1	2	5	4	1332
Nes	0	56	37	738	342	0	67	431	0	0	1	0	1672
Sum	4228	2607	747	17737	10372	756	1378	9404	109	537	125	130	48130

Table 1: Contingency table from underlying dataset of the analysis, providing sum of individual variables and for variables at site level. The variables are - 1: Sea, 2: Freshwater, 3: Wetland, 4: Forest, 5: Clay, 6: Terminal moraine, 7: Dry grazing land, 8: Suitable agricultural soil, 9: Grave context, 10: Rock art, 11: Finds, 12: Other sites.

3.4 Dataset analysis

To address question of human-environmental engagement and explore affordances in the data on an overall level, I employed the methods of correspondence analysis (CA). The goal of this methods is to reduce or compress multivariate information into a particular (two-dimensional) point of view, and hence necessarily losing some information. Therefore, the results need always be doubled checked by returning to the raw data.

The correspondence maps make visible some general trends, which considering the two first dimensions of the CA account for 61.7 % of the inertia (Figure 2) can be regarded as reflecting through patterning. Based on the large difference between the present and absent of the variables (Table 1), they necessarily contributed somewhat differently (Figure 3 and 4). The red lines in the figures indicates the expected average contribution. Demonstrating the the variables 'sea', forest' and 'clay' are considered important, as is 'suitable agricultural land', while the cultural variables are less important in the CA plots. As the most major results of the original paper are connected to these variables, I regard the results as significant.

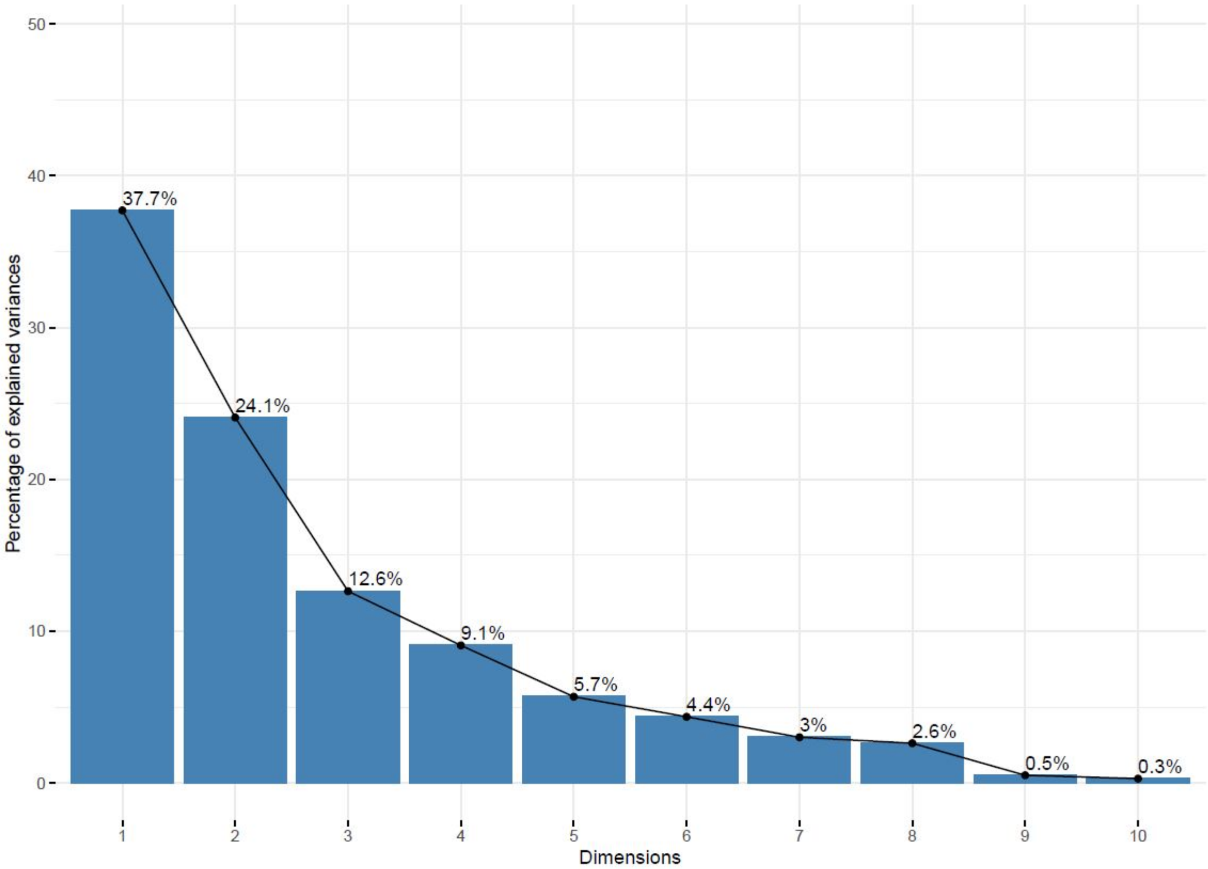

Figure 2: Scree plot showing how much variation the two dimensions of the CA captures.

It is nevertheless important to always double check any of the observations presented in the CA to account for their real significance and the relevance of any present relations, and I always returned to the raw data throughout the analysis. I also added a second analytical step in my data treatment to account for the observations in the CA, graphically visualized in scatterplots and boxplots, which also provid important information on distance data. Scatterplots have the capability of visualizing several of the variables or sites at the same time according to their median data, boxplots offers more detailed data on each of the variables.

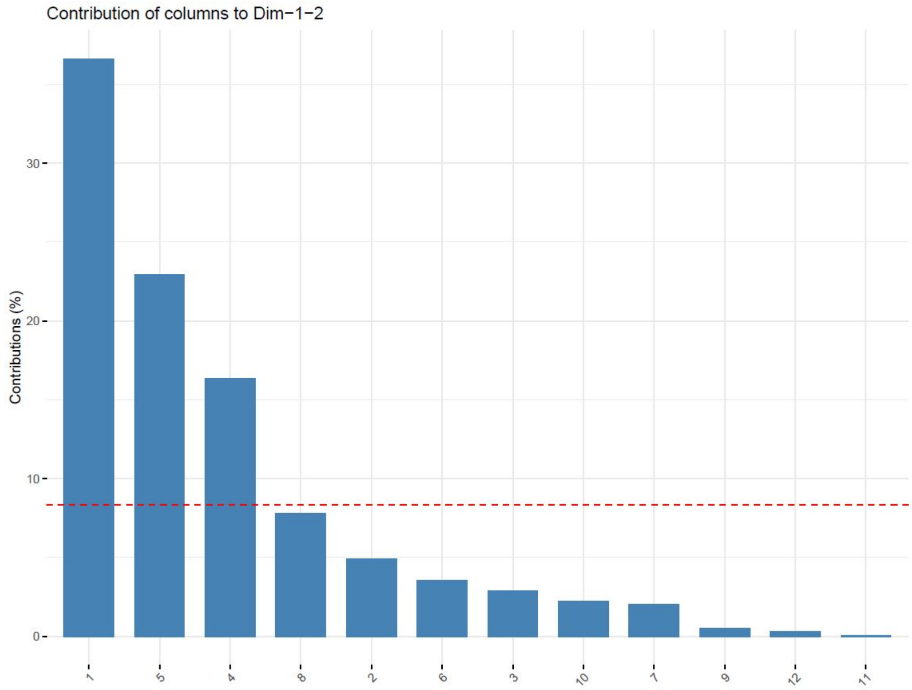

Figure 3: Contribution of variables to the CA.

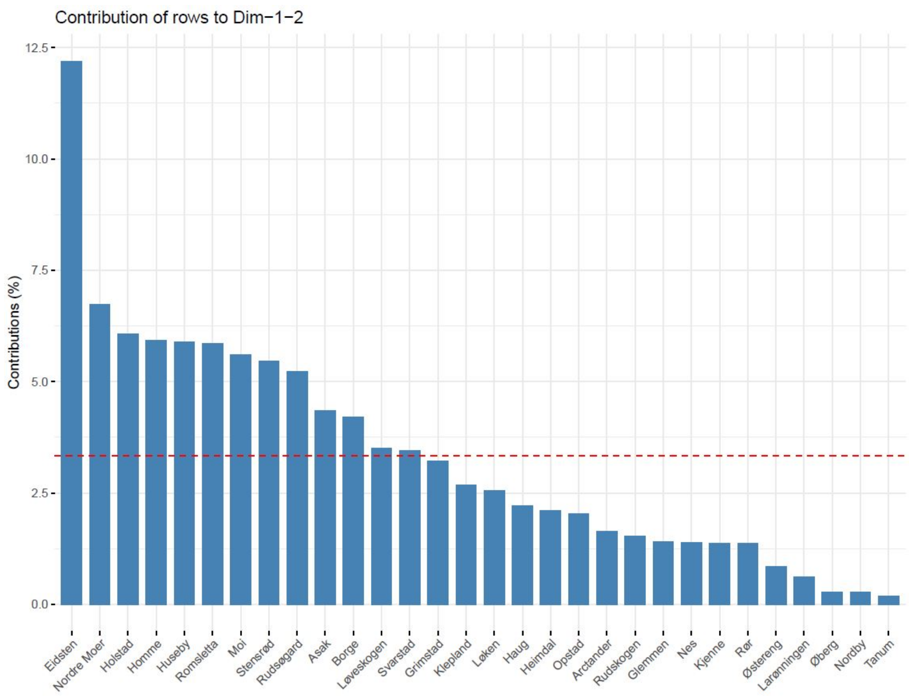

Figure 4: Contribution of site to the CA.

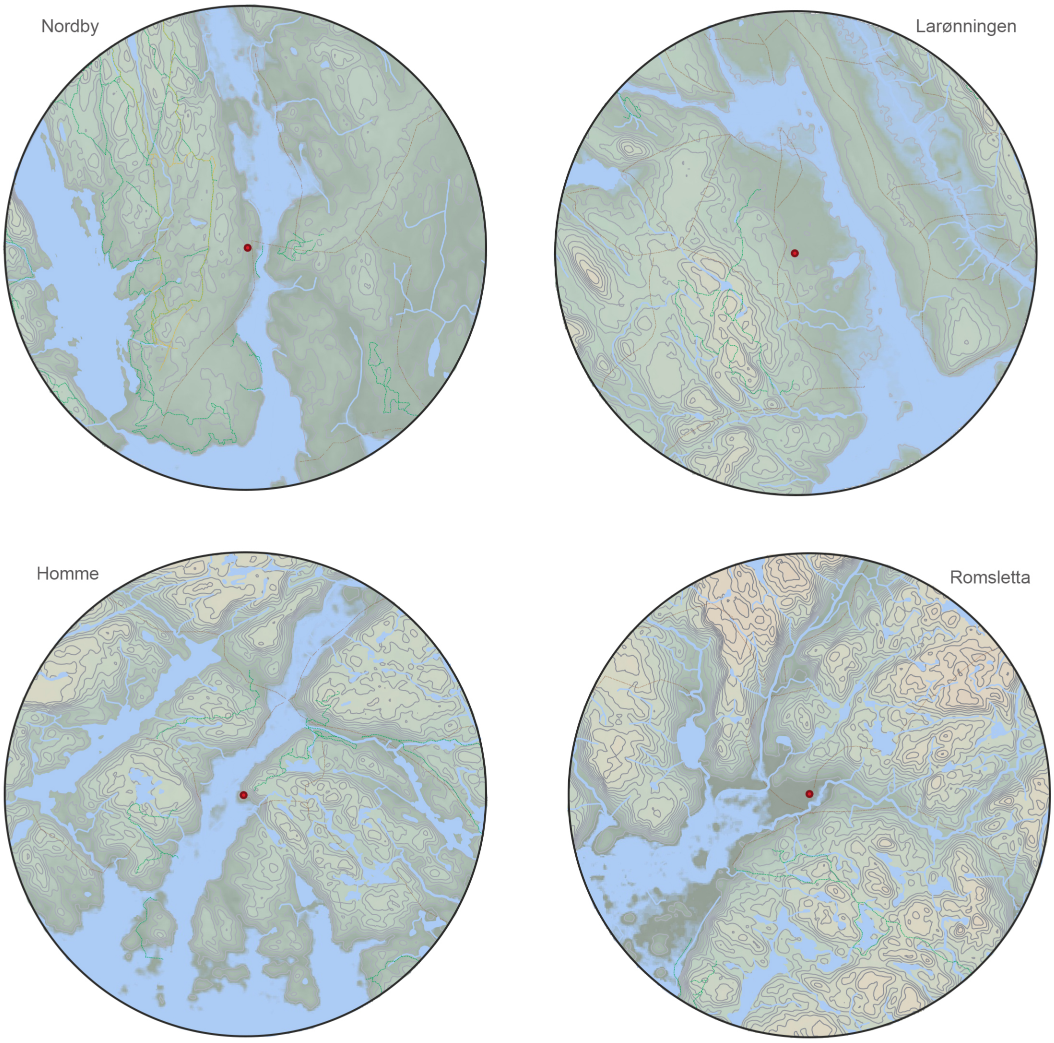

Figure 5: Topographic maps of four selected sites based on temporal representativity within same area. Nordby (LN-EBA) and Larønningen (LBA), although from different districts are rather close to each other on the western side of the Oslo Fjord, while Homme (EBA) and Romsletta (LBA) are from the southernmost part of the study area, the county of Agder (maps by author)

3.5 Possibilities and constraints

In addition to the individual sites ID and variable numbers (as used in the main article, but also see caption for Table 1) the combined datasets (which is available in repository) include information on individual point ID and the points distance from settlement site, which is important for this particular study as distances to certain variables could be highly meaningful. Something which would not have been possibly if using a method calculating areal coverages of the variables. By including the individual point IDs, the data also holds potential to derive information on the cardinal direction of variables in relation to the settlement site, but also to each other – either at large or on more singular level. This can, for example, be used to search for direct overlap between variables rather easily through the point IDs, allowing for detailed analyses of variable relations and compositions, also beyond this study.

A fault of the method is it somewhat static representation of the environment, and particularly its lacking ability to consider topography. As of now, the method can only reveal particular features through the absent of data, for instance rocky terrain, such steep hills and mountain sides. This is likely the case in the above example (Figure 1), with lack off data nearby the sea as indicative of e.g., skerries. Throughout the analysis, I therefore consulted topographical maps (Figure 5) in my analysis.

To account for the possibilities of movement within the zone, I also added data on available paths, tracks, and historical roads to these maps. Although not necessarily equivalent to those existing in prehistory, they are accumulated imprints of human journeys and taskscapes made visible (Ingold, 1993, 167) and can provide us with an idea of which spaces afforded movement in relation to the settlement sites. I did, however, not find a way to make this part of GIS analysis, but see it as possible way to improve upon the underlying phenomenology of the method.

4 Conclusion

The developed method is well-suited to get an overview of landscape surrounding the settlements, and provides a more nuanced understanding environment in which people decided to settle down and lived their life. I would argue that the method can be used a mean for approaching past experiential settings more quantitatively, and it is particularly suited if the means is to specifically attribute information on distances.

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