THE ECOLOGICAL CONSIDERATIONS FOR THE PLACEMENT OF HINDU-BUDDHIST ERA SITES IN THE REGION OF YOGYAKARTA: A MACRO-SCALE STUDY USING SPATIAL ARCHAEOLOGY

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Summary

[This summary was part of] a dissertation submitted in order to obtain a Doctorate of Humanities in Archaeology at the University of Indonesia in Jakarta under the leadership of the Rector of the University of Indonesia Professor Dr. Sujudi. The thesis [was] defended in front of a panel of University of Indonesia Professors on Saturday, 5th June, 1993, at 10:00 am.

1. Rationale

Archaeologists have long studied and paid special attention to the relationship between humans and their environment in the past. This is why many common ecological principles are being used in various archaeological lines of research inquiry (Hardesty 1980; Kirch 1980). As these kinds of studies are connected to a human past that is no longer extant, a methodological problem that is often raised by many is how we might acquire an understanding about the presence of such a relationship, and what kind of relationships might have occurred during that period. Among the important research questions that Archaeologists might consider important enough to examine is how natural resources might have been utilized to meet human needs. Such a study would include a consideration of ecological factors that humans utilized within various human activities which would fulfill their needs, both with respect to the acquisition of food, protection, as well as their own sense of locationality (*penempatan dirinya*) to the land, which would include the placement of buildings as venues in which to conduct activities.

This study is but one small effort to develop analyses in spatial archaeology in our country, particularly at the regional (macro) scale, as well as those conducted with strategies and methods that are in accordance with the nature of spatial archaeology that is present in Indonesia. One should be made aware of the fact that without conducting this type of research, the development of studies in spatial archaeology for Indonesia would undoubtedly be extremely slow, so much so that the research would be left far behind as compared to similar studies in other countries.

Spatial Archaeology, which is a specialized study in the field of Archaeology, generally focuses more attention on the study of the spatial dimension rather than the study of the formal and temporal dimensions for archaeological artifacts and sites. In the history of global archaeological development, the study of spatial analysis for archaeological artifacts and sites came about later than the study of its formal and temporal dimensions. Accordingly, for the last four decades in the realm of archaeology, there has been a shift in focus from artifact studies towards the study of sites, which in reality consists of a specific spatial grouping for the location of a group of artifacts.

Subsequently, in the next phase of archaeological development, much attention was given to the study of regions as a larger spatial unit, particularly for site location analysis (Dunnel and Dancey 1983: 267). The attention given to the spatial dimension is what led some archaeologists to shift away from morphological, typological, and classificatory studies of archaeological artifacts to the attempts to recover spatial information as the basis for further detailed studies, whether it be from archaeological artifacts that were found in a single spatial unit like sites, or sites found within larger spatial units such as the region.

Apart from that, studies in spatial archaeology places more emphasis on archaeological artifacts as groupings or clusters within a spatial unit rather than as stand-alone objects. A good understanding of past societies and cultures cannot be obtained if we merely focus on archaeological artifacts on their own; it will need to include the totality of archaeological evidence that was found in a site, whether it be artifacts, ecofacts, features, and the physical environment as a spatial unit of analysis. In other words, archaeological interpretations will be more accurate if seen from a contextual perspective, which Taylor termed the *conjunctive approach* (Taylor 1973: 5).

Studies in spatial archaeology therefore does not place emphasis on archaeological objects as single entities, but instead, places emphasis on artifacts and the distribution of archaeological sites, then the relationship between artifacts and between sites, and finally, the relationship between objects or sites with the physical environment as a resource. Spatial archaeology not only studies the locational relationship or the spatiality between artifacts, but also with and between other forms of archaeological data, which Clark (1977: 11-17), on the whole, termed as elements. These elements consisted of structures or features, sites, and the way in which the physical environment was utilized as a resource.

The basic concept which is contained within the definition of spatial archaeology came about during the history of archaeological development as archaeologists gradually realized that archaeological data could be obtained not only from the elements contained within archaeological artifacts or sites alone; the data could also be obtained from the spatial relationship between archaeological artifacts or between archaeological sites. The shift in attention from entities to the relationship between entities, as mentioned as above, was the reflection of one assumption in which artifacts should not only be seen as an object in its own regard, but also as a mediator which links humans to other aspects, such as that of the environment (Watson et al. 1971: 87).

Spatial archaeology attempts to study the distribution and spatial relationship of various types of centers of human activities, whether it be at the micro scale, where one studies the distribution and locational relationship between archaeological objects and spaces within a building or feature; at the meso or semi-micro scale, where one studies the distribution and locational relationship between artifacts and features within a site; or at the macro scale, where one studies the distribution and locational relationship between archaeological artifacts and sites within a region.

2. Research Questions

The sites that are being examined in this study are sites which contain ancient relics, such as buildings and/or their elements. In Indonesia, during the Hindu-Buddhist era, monumental architecture—which were made from durable materials (whether it be of stone or brick materials)—were considered sacred buildings known by the name of *candi* (temple) or *kuil* (shrine); these were venues or centers of religious activities (Soekmono 1974) which were held for the benefit of its community of supporters. The research results regarding temple formation, size, style, and others—along with the research regarding temple use or function—gives us clues as to the presence of a system of ordering, and may, at once, form the basis in which to start thinking about the existence of a common set of rules which were used by past communities as a guideline for temple construction (whether it be written or unwritten). In that sense, there are many things that still need to be understood and revealed; this would include the behavior and ideas of past peoples in relation to temple construction. For example, how might people choose certain plots of land for the location of a temple building? Would certain physical environmental conditions be important factors for consideration when making the decision to locate a temple?

In the *Mānasāra-Śilpaśāstra* text, which contains the rules for temple construction in India, there are a series of detailed passages which basically explains the need to assess a prospective site for its land potential and condition prior to a temple building being erected (Acharya 1933: 13-21; Kramrisch 1946: 3-17). Similarly the *Mānasāra-Śilpaśāstra* text also explains that the placement of the temple must be close to sources of water, as water has the potential to cleanse, purify, and nourish. Even according to the *Śilpa Prakaśa* text, it is stated that erecting a temple in a plot of land without a nearby river ought to be avoided (Boner and Sarma 1966: 10).

With the information exemplified by the passages from the *Mānasāra-Śilpaśāstra* and *Śilpa Prakaśa*, one may infer that the land and water potential would continue to play important roles in the decision making process of past architects as it relates to the site selection for the placement of every religious building. The land potential factor was of such importance to the founding of a religious building that Soekmono's following statement seemed to confirm it: "Any sacred place is sacred because of its own potential. Therefore in truth, the land is of primary importance, whereas the temple merely occupies a secondary position" (Soekmono 1974: 330).

Based on the written information and the archaeological field data from Indonesia, which were shown as above, therefore the general hypothesis which was selected for further examination for this study can be formulated briefly, as follows: the site selection for the location of a temple building and its surroundings takes into account natural resource potential. Furthermore, if we look at the issue from a macro perspective towards the distribution of temples within one region, then the general question can be summarized to be: the temple site distribution has a strong correlation with the distribution of natural resource potential; in other words, the distribution patterns of temple sites are in accordance with natural resource distribution patterns. The region which was used to evaluate the natural resource potential of temple sites and its surroundings—as was intended in this research—is often referred to by geographers as South Merapi, which includes the district of Sleman and Bantul, within the Special Province of Yogyakarta. On one hand, while initial observation results indicate that the natural resources in this area are not uniform, on the other hand, the distribution of temple sites—whether it be those that are still standing or those that have been damaged or are in ruins—have turned out to be uneven, and often in groups with different site densities. In line with that expression, the question that is posed in this study is: what is the relationship between temple site location and the natural resource potential for the Sleman and Bantul areas, particularly in terms of observable and measurable abiotic resource variables?

3. Analytical Framework

As mentioned above, this study attempts to examine a large number of temple sites in the region of South Merapi, particularly in terms of distribution patterns and its correlations. This would mean that in its examination, this study not only looks at temple sites as single stand-alone entities, but one that looks at every site in totality within a vast region. These sites were not studied, for example, from the aspect of shape and extent (in order to answer the questions regarding "what" and "what size"), nor from the aspect of time and period of occupation (in order to answer questions of "when" and "how long"), but from the aspect of its location on the landscape of the research area (in order to answer the question of where sites were located, and why might such a distribution pattern exist).

The distribution of these sites, whose pattern can be observed directly in an empirical manner (*observed pattern*), in this research can be considered one of the products that accumulatively came in to being during the Hindu-Buddhist period in Central Java, at least for a period of approximately 200 years, from the 8th-10th centuries. The site distribution is thought not to be random, but patterned, as in general, communities do not randomly locate a site, but locates a site within certain parameters which follow general rules (as exemplified by the ancient Indian temple construction rules) that occurred in (*normative*) society (Watson et al. 1971: 61). The pattern of site distribution is thought to be the actualized concrete form of the regulations and the distribution of religious sites in the research area. The spatial patterning from archaeological sites may reflect past human activity patterns (Schiffer 1972: 156).

In addition, at the operational level, this macro or regional research strategy uses an approach that is known in archaeology as the ecological determinants approach (Thomas 1979: 300), which focuses principally on the analysis of the diversity of site distribution patterns.

The ecological determinants approach (which is not ecological determinism) does not assume that the physical environment determines all aspects of culture, but rather, it assumes that a set of specific environmental factors within a region gives conditions as to the placement of archaeological sites. The ecological determinants approach simply considers that past human settlements are often placed within a particular landscape as the answer to a specific set of environmental factors which play a role in determining the placement. However, this does not mean on the whole that the environmental aspect is the only factor which influences or determines the placement of archaeological sites.

With this kind of approach, the site distribution pattern of archaeological sites in the research area is therefore assumed to be associated with past natural resource use patterns, and this pattern may be orientated to the concept of energy minimization and work maximization (Clarke 1977: 19). Therefore, the temple site distribution pattern during the Hindu-Buddhist period in the research area is thought to be associated with the distribution pattern of natural resources in a varied manner, and will result in varied relationship patterns as well. In other words, the archaeological site distribution whose associations vary with natural resource patterns is assumed to not to display a random pattern as it will be influenced by physical environment factors which exist at the location of the archaeological sites (Hodder 1977: 224).

4. Objective

In order to understand past cultures and communities, the majority of archaeologists in various parts of the world would be in agreement with the notion that the science of archaeology has three main objectives, which are: (1) the reconstruction of cultural history, (2) the reconstruction of the ways of life, and (3) the depiction of the cultural process (Binford 1972: 78-104).

The study of spatial archaeology which was intended for this research focuses particular attention to the pattern of association between the distribution of temple sites and the distribution of natural resources; additionally, it will pay attention to the shape of distribution patterns. As such, in terms of common archaeological objectives, which were stated as above, this study can mainly be categorized into attempts to reach the first and second archaeological objectives; however it is not clear whether this study can be categorized as an effort to reach the third archaeological objective, which is diachronic in nature.

In the meantime, according to the issues that have been raised, this study attempts to achieve specific objectives, namely:

1. To understand the correlation between the natural resource potential which exists at temple sites by holding to ecological consideration principles. These principles were stated within ancient Indian texts regarding regulations.
2. To further understand the variation in environmental potential which existed at the temple sites; the variation in environmental potential could reflect the selection variation of past humans when they chose certain locations for those religious buildings. It is with the physical environment variables that one may find which variables or variable clusters can be found within temple sites, in order to understand which sites have a physical environment with poor, fair, and/or good potential, and whether the variation was stated along the principles of the *Mānasāra* text.

As such, it is hoped that we will be able to gain some knowledge regarding the application of ecological considerations that were made by past builders when they determined the location for religious buildings, along with the variety of options, or in other words, this study is an attempt to interpret the wisdom of past communities in terms of temple placement during the Hindu-Buddhist sites for the research area in question.

It is hoped that this knowledge would be utilized as the basis in which for stronger hypotheses can be generated, which would then be re-examined in subsequent (generative) studies, such that subsequent research cycle can result in higher and deeper levels of analysis.

5. Benefits

The spatial archaeology approach does not mean that the approach is more important than other perspectives; rather, that type of perspective might be useful for a variety of things regarding: (1) the development and application of theory, methods, and techniques for Indonesian archaeology, (2) the development of avant-garde knowledge that is needed to reveal the human past, particularly eco-archaeology and geo-archaeology, (3) the provision of regional data and resources for future studies (including 18 thematic maps), and (5) providing means by which to strategize the preservation, protection, and security of sites and the data that may incur negative impact due to physical construction activities. These would be in line with our goals whose core ideal is stated in the articles of the Regulations for Cultural Heritage (*Undang-Undang Cagar*

Budaya). The expansion of our knowledge horizons regarding the society and culture of Indonesia of the past must continuously be developed.

This research has resulted in fairly accurate site distribution maps, which has never been made in such a complete manner. These types of maps, along with the information contained therein, is surely useful for: (1) planning more solid spatial archaeology research strategies at the macro level, whether for this research area or other areas, or a more detailed research strategy that can deepen and refine research questions at smaller (meso and micro) spatial scale, and even develop comparative and diachronic research strategies in order to understand cultural processes; (2) planning strategies for the use of sites as an economic resource in the scope of developing tourism and regional development.

6. Research Methods and Techniques

Research Area Selection

The research area which will be the subject of interest for this regional study lies between the Opak Canal (*Kali Opak*) on the east side and Progo Canal (*Kali Progo*) on the west side, and between Mount Merapi at the north side and the Indian Ocean at the south side. Administratively the research area lies in the Sleman district (the northern section) and the Bantul regency (to the south), within the Special Province of Yogyakarta. It should be noted that as there are various intensive taphonomic activities in the municipal region of Yogyakarta, the region which lies in the middle of the two districts will not be included in this study.

The choice of the Sleman and Bantul districts as research areas was predicated on certain considerations, which are as follows: (1) the research area needed to be relatively small enough for researchers to manage conduct site surface surveys; (2) the research area needed to contain a large enough number of sites to allow for the possibility of a sufficient generalization; (3) the research area needed to be between the Opak Canal and the Progo Canal, which had a range of natural resources (from volcanic mountain peaks and its slopes to the foot of the mountain, plains, and beaches to the south); most of these areas have been shaped by and dominated by volcanic material (from Mount Merapi), which for the most part until today, erupted in a similar manner, and (4) the research area would be easier to handle as it is within the scope of the research center in Yogyakarta.

The total area of the research area (which consists of the *data universe*) is approximately 1,018.25km^2. This study did conduct sampling; instead, total survey methods were employed throughout the research area by sweeping the region, even though it was undertaken only by two surveyors. The currently known number of sites which can be accounted for in this study amounted to 218 sites (which consisted of a *population survey*; Read 1975: 52).

If one simply looks at number of finds from archaeological sites that were categorized as having been a part of the Hindu-Buddhist period, one might see that there are actually a large number of archaeological sites that are spread out within the study area. For this paper the terms "site" and "archaeological site" are synonymous with the term "temple site." Moreover, the third term refers to an understanding of archaeological remains that are characterized by the cultural influences of the Hindu-Buddhist period.

In line with the research purposes and the reality in the field in particular, therefore in this study, an area of land can only be categorized as an archaeological site if the area contains:

1. Archaeological remains which include static objects, such as temple buildings, whether it in whole or partly intact; whether fully standing upright, incomplete, or down to its foundations, so long as they can be classified having been located in situ;
2. Archaeological remains which fall into the category of move-able objects but consist partly or are elements of static objects, such as the wings of a staircase (*pipi tangga candi*), and as such, can be said to lie in situ;
3. Archaeological remains which consist of moveable objects, such as ceremonial objects or sculptures, which were originally from the site and whose provenance can be ascertained with a high degree of certainty. This means that a site which contained stray finds that did not consist of building elements and whose provenance in situ is in question will not be considered as a site in this study.

In line with the research goals, which are to connect site location variables with a set of physical environment resource variables, a survey was conducted on the factors of the physical environment which were made of variables which could be observed and measured.

The majority of the data for the physical environment in the study area was the result of a 1987 geo-archaeological research project (Sutikno et al. 1988), which contained information related to landforms, soil types, rock types, groundwater, and springs (*mata air).* This data was used as the basis for further analysis in conjunction with other data that were acquired for this study in spatial archaeology.

Existing data on land potential was obtained from the soil use map which was compiled by the Land Use Directorate (*Direktorat Tataguna Tanah*) of the Agrarian Directorate General (*Direktorat Jenderal Agraria*). Moreover, data on altitude, terrain gradient, the distance from the site to the river, and the distance from the site to springs were obtained through available topographic and hydrology maps.

The nine natural resource variables which will be researched in this study are height, terrain gradient, landform, soil type, rocks, land potential, existing groundwater, the distance to rivers, and the distance to springs.

Data collection

Data collection activities in this study began with a literature review, which was conducted in order to acquire locational data as well as natural resource data for the research area. The data collection included checking out the library as well as maps. The literature review was conducted in order to gather environmental data, which included climate data (such as rainfall and temperature), groundwater data, and aquifer characteristics.

Natural resource variables were obtained and observed using a number of false-color infra-red aerial photographs at the scale of 1:30,000. Natural resource data such as geology, geo-morphology, land use, soil type, and river flow patterns were obtained from these photographs. Topographic maps were used to prepare a base map and in order to obtain detailed water flow pattern data. Geological maps were used to test the results of aerial photograph inferences regarding geology, and hydro-geology maps were used to estimate the relative groundwater potential. Meanwhile, piezometric contour maps (*peta piezometri*) were used in order to obtain a general overview of the distribution of groundwater depth in the research area.

Field Data Collection

Based on the lists and maps which were mentioned as above, a field survey was conducted. The survey was meant to: (1) check on the presence of archaeological sites mentioned in the literature; (2) to match the names, types, and number archaeological finds which currently exist and those which were once there, and adding new site locations which were found incidentally; (3) to obtain locational data from the sites and geographic environment situation in a broader manner; (4) to place visited site locations on a map in order to determine the astronomical position and elevation more precisely.

Field data collection was also conducted in order to obtain data on a range of natural resources regarding: (1) land form types; (2) soil types through observation and soil sampling for laboratory analysis; (3) current land use; (4) ground-water, permeability, and springs, by coring; and (5) electrical resistivity, in order to determine groundwater potential.

Data analysis

In an effort to examine the relationship between site locations and the natural resource location units, therefore a distribution map of Hindu-Buddhist era archaeological sites was superimposed (using an overlay technique) on a map containing landform types, soil types, rock types, soil potential types, groundwater, terrain gradient, and elevation.

The analysis of this data looks at the site frequency of Hindu-Buddhist temples against landform types, groundwater types, geological rock types, soil types, soil potential types, types of elevation, terrain gradient types, distances to rivers, and distances to springs.

In spatial archaeology the representation regarding archaeological artifact and site distribution is commonly stated with the degree of distribution or the dispersion from a number of objects and archaeological sites which are found within a spatial grouping with specific boundaries (Cox 1972: 193-194). Site distribution dispersions can be generally stated into three common patterns, namely: the random pattern, the clustered pattern, and the regular, or uniform pattern. By paying attention to the extent in which the distribution is dispersed, site configuration patterns may be measured in the research area, particularly by using the nearest neighbor analysis method (Hodder and Clive Orton 1976: 38-51; Bintarto and Surastopo Hadisumarno 1979: 74-80).

As noted this study will examine a number of large sites with a set of natural resource variables. For every site that is examined, data regarding at least nine natural resource variables with 58 classificatory values will be needed. As such, for the 218 sites which will be examined in this study, thousands of numerical data will need to be analyzed. It would not be easy or efficient to manually work on data sets which are multivariate, which are partly qualitative, scalar, or categorical. There needs to be a technique for analyzing data statistically with the aid of a computer program which will be able to summarize and simplify thousands of numerical data, and even explain the trends that may appear from the analyzed variable associations.

The data analysis technique which was used to obtain a picture regarding the relationship between site location variable and natural resource combined variables was the correspondence analysis (*analyse de correspondances*). Correspondence is understood as referring to the system of association between the row profile values and column profile values. The correspondence analysis method, as proposed by Michael J. Greenacre, did not analyze data on the basis of one particular a priori model, but instead, it works within the framework of assessment with the main goal of finding patterns that present themselves as the result of processing the data (Greenacre 1984: 4, Jambu 1991; Lebart, Morineau, and Warwick 1984).

7. Research Results

Site distribution patterns

The result of the survey illustrates the density of archaeological sites from the Hindu-Buddhist era in the research area, which included the administrative regions of Sleman and Bantul (which does not include the municipal area of Yogyakarta). In the Sleman Regency, which is 584.82 km^2 wide, 181 sites were found, while in the Bantul Regency, which had a similar area size of 443.43km^2, only 37 sites were found. As such, the the figures for site density in the Sleman Regency is on average 0.31per km^2, while in the Bantul Regency, it is 0.08 per km^2. This means that in the Sleman Regency for a site would occur every 3.2km^2, while in Kabupaten this would only occur every 12 km^2.

Archaeological sites can be found among all of the 17 districts that are in the Sleman Regency. Therefore, with a total of 181 sites, there are would be 11 sites on average for every district in the Sleman Regency.

In the Bantul Regency, which is comprised of 17 districts, there are 12 districts, or 70.59%, which contain archaeological artifacts. As there are 37 sites in total, each district in Batul would have 2 sites on average.

Among the 86 villages / sub-districts that are in the Sleman Regency, 61 villages / sub-districts or 71% are known to have archaeological sites. With a total of as many as 118 sites, an average of 2 sites are found in every village / sub-district area of the Sleman Regency. On the other hand, among the 75 villages / sub-districts in the Bantul Regency, 21 villages / regencies, or 28%, are known to have archaeological sites. With a total number of 37 sites, therefore each village / sub-district area in the Bantul Regency would contain 0.5 sites, or in other words, for every 2 villages / sub-districts, there would be one site.

A general indication regarding the site density can also be seen based on the grid groupings on the research area map which is 9x9 km each, or 81km^2. The site density shown generally indicates that the frequency of sites for the Sleman District, which are found in every grid, are of a larger number than those found in the Bantul Regency.

With the use of simple observations towards site distribution maps, we are able to obtain a relative representation of the degree of dispersal. The variation in the site distribution degree for this area will surely be interesting to take note of, and as such, should be studied further using more refined observation methods, such as the nearest neighbor analysis. The results of the nearest neighbor analysis gave us an idea that the site distribution degree or configuration for each grid in the Sleman and Bantul Regencies all had clustered patterns, except in two grids (i.e. grid 9 and grid 21), which consisted of random patterns.

The Correlation of Every Natural Resource Variable with Sites

In the research area, sites were situated at along a fairly long range of varying altitudes, consisting of the lowest elevation at 6 meters, to the highest t 540 meters above sea level. Generally, of the 218 sites, 162 (74.3%) are clustered at an altitude less than 200 meters, and there are 56 between 200-1500 meters (25.7%). However there are no sites which are of an elevation higher than 1500 meters, which could be said to be the highlands.

The data suggests that the higher the location of the, the less sites there are; conversely, the lower the elevation, the more sites there are. There is a large probability that the data points to a close correlation with a number of vegetation variables. The numbers of vegetation types which grow at high elevations tend to be much lower than those that grow in lower elevations (Verstappen 1983: 88). The tendency of humans to primarily choose areas with relatively low elevation with a greater variety of plant types might have happened in the distant past, as those areas have the potential to set up residences and cultivate plants well, which also occurs in the present.

Terrain gradients and Sites

In this study the terrain gradient classification is divided into several classes, which are: (1) less than 2%, (2) 2-15%, and (3) more than 15%. The categorization of the terrain gradient data into the three classes revealed nearly all of the sites, that is, 154 sites, or as much as 70.6% of the total population is located in areas with surface terrain gradient of between 0 (flat) to 2% (gently sloping).

Based on empirical data, one can surmise that flat and gradient areas are places that were utilized most by people during that time to place centers of activity. There is more freedom to move in those areas compared to areas with slanted, slightly steep, steep, and very steep terrain gradients. In flat and gently sloping areas, the run-off water will flow more slowly without causing topsoil or soil surface erosion, which settlers and agriculturalists tend to avoid.

Landforms and Sites

In the research area there are only 11 landform types that contain archaeology sites. The site frequency according to landforms states that there are 101 (46.3%) sites on fluvio-volcanic plains, 51 (23.3%) on the terrain gradient at the foot of the fluvio-volcano, 41 (18.8%) on lower slopes the volcano, 7 (3.2%) on escarpments or faults (*dinding terjal / sesar*), 8 (3.6%) on the slopes on the volcano, 4 (1.8%) sites on structural hills (*perbukitan struktural*), 1 (0.5%) site on alluvial plains, 2 (0.9%) sites on natural levees, 1 (0.5%) on flood plains, 1 (0.5%) on denudational hills, and 1 (0.5%) on isolated hills (*perbukitan terpisah*). Based on that data, it can be concluded that the fluvio-volcanic plain landform, the foot of the volcanic slope, and the lower slopes of the volcano are three of the most desirable landforms as places or centers of activity by the majority of past societies. This fact is understandable as geomorphologic processes which occur on the said three landforms are relatively harmless, whereas the topography ranges from flat to gently sloping, with good drainage, and would contain fertile material resulting from the eruption of Mount Merapi.

Land and Sites

In the study area there are six types of soil types which contain archaeology sites. Out of the total of 218 sites, 103 sites, or 47.2% lies on regosol soil. Meanwhile, there are 99 (45.4%) sites on kambisol soil, 4 (1.8%) on alluvial soil, 10 (4.6%) on latosol-grumosol soil, 1 (0.5%) on latosol soil, and 1 (0.5%) on litosol soil.

The kambisol and regosol types were used to locate centers of past community activities with greater frequency as compared to the other 4 soil types. This empirical fact is more easily understood as kambisol and regosol soil types have a high degree of fertility and are suitable for agriculture. Regosol soil, which is highly porous, results in high permeability, and as such, the groundwater potential is also high, similar to the upper slopes and the lower slopes, until the foot of Mount Merapi.

Alluvial soil is quite fertile as well, but empirical evidence shows that the area only contains 4 sites, or 1.83% of the site population. Floods often plague alluvial lands, which may be a consideration for people in the past not to place sites on that type of land. Meanwhile, the latosol-grumosol complex soil type contains low permeability and as such, has low groundwater potential. Therefore, it makes sense that there are only 10 sites located on this kind of soil type.

Rocks and Sites

In the study area, there are only 4 types of categories for all 218 sites. When one looks at the site frequency, there are 201 (92.2%) sites located on young volcanic sedimentary rock, 11 (5.0%) on napalan limestone, 5 (2.3%) on alluvium, and 1 (0.5%) on breccia.

The rock type with the widest distribution in the study area is volcanic sediment. These rocks are formed from the sediment of lava whose texture varies from medium to coarse, which allows for the availability of groundwater in large quantities. Other than that, there are other sedimentary rocks which are napalan limestone rocks and breccia. However, the distribution of the three types of sedimentary rocks is not very wide. In those sedimentary rock areas, the amount of groundwater content is very little or not available at all. As such, in those areas, it is very difficult for people to get water, which is also the case in the present. This is contrast to areas with alluvium, where there are abundant amounts of water.

Land Potential and Sites

In the research area there are 12 types of land potential which are categorized on the basis of effective soil depth, soil texture, drainage, and erosion. However, there are only 6 types which contain sites. When one looks at the frequency of sites by land potential, 180 (82.6%) are found on A3aT, 20 (9.2%) on A2aT, 7(3.2%) on A1aT, 7 (3.2%) on C1aT, 3 (1.3%) on B2aT, and 1 (0.5%) on C2aT. The type of land which contains the majority of sites is A3aT, with an effective land depth of more than 90 cm and a coarse soil texture.

Groundwater and Sites

From the 9 types of groundwater potential that exist in the research area, only 7 types contain archaeology sites. In terms of site frequency by groundwater type, there are 85 (39.0%) of A2, 8 (3.7%) of A3, 3(1.4%) of A4, 1 (0.5%) of B1, 40 (18.3%) of B2, 71 (32.6%) of B3, 10 (4.5%) of C2.

The empirical data as mentioned above clearly shows that 196 sites, or 89.9% of the total, are within areas whose water potential was classified under A2, B3, and B2. Whereas there are only 22 sites or 10.1% of the total found on C2, A3, A4, and B1 groundwater types. With this data, it can be concluded that the 3 groundwater types which were mentioned first were utilized by people as centers of activity during the Hindu-Buddhist period rather than the 4 latter types.

In the research area there is also variation in the surface groundwater depth measurement, which can be categorized by the level of difficulty in obtaining it. In terms of site frequency, there are 96 sites (44.0%) found on areas with a groundwater depth of less than 7 meters, 112 (51.4%) sites found within areas with a groundwater depth of between 7 to 15 meters, and 10 (4.6%) found within areas with a groundwater depth of more than 15 meters. From that data, it can be concluded that the areas which contain the groundwater depth of less than 15 meters contains 208 sites, 95.4% of the total, or nearly all the archaeology sites.

The aquifer layer in the research area, which is mostly dominated by the deposits of volcanic rock, contains 4 levels of permeability which are: very high, high, medium, and low. We now know that the lands with a low aquifer permeability (5.0%) and very high (1.4%) traits only contained by a small number of sites. However, it is still not well understood why there are large amounts of archaeological sites in areas with medium groundwater potential, such as A2, B2, and B3 groundwater types, while there are few sites in areas with high permeability.

Perhaps from the empirical data, it can be interpreted that during that period, groundwater was not the only water source that was needed in order to fulfill basic societal needs. The presence of river water and other more easily retrievable sources of surface water may be a consideration which is commensurate with general technological level of the community of the time. Besides that, we know that other than the ease of acquiring water, the placement of archaeological sites may be influenced by other natural resource factors such as the flatness of soil surface, soil fertility, and other factors which give certain advantages. Water quality for the

Hindu-Buddhist period may not be an important consideration when choosing activity areas, given that there is good quality of water in nearly all volcanic areas. In areas which contain low groundwater potential types (B1 and C1), the number of archaeological sites are indeed quite low.

The River and Sites

Besides examining the relationship between site distribution and groundwater, this study also tried to look at the relationship between the placement of archaeological sites and the location of surface water sources, the river. The results of the distance measurements between sites and the river indicates that there are 179 (82.1%) sites with a distance less than 500 meters, 25 (11.5%) had a distance of between 500-1000 meters, and 14 (6.4%) sites with a distance of more than 100 meters.

The data indicates that the largest number of sites is found within a distance of less than 500 meters. This data suggests that the river provided for basic human needs, whether it is for everyday life or for other needs, such as to provide rock materials for the construction of temples. From the survey results, it suggests that the construction materials for the sites in the north of the research area are made of andesite, while sites in the south are made of bricks. This data suggests there may be a very strong correlation between the locations of temple sites and the river. This is understandable as rivers in the north contain a number of large sizeable andesite blocks, while in the south, the rivers contain small rocks. In the sites to the south, buildings are made of bricks that contain andesite objects. These objects may contain certain elements of temple construction such as statues, yoni, lingga, and jaladwara.

Springs and Sites

In the northern region of the research area, there are many springs which are known in geological and geographic terms as the contact spring. Its presence is closely related with the stratovolcano type, as such, the configuration for the distribution is shaped like spring belts (Purwohadiwijoyo 1967). If the site is located close to the water source, the distribution of sites in the north may also have a similar distribution. The results of the distance between site location with springs indicates that there are 23 sites (10.55%) with a distance of less than 500 meters, 30 sites (13.76%) with a distance of between 500-1000 meters, and a majority, or 165 sites (75.69%) are located in distances of over 1000 meters.

Through the empirical data which was mentioned as above, information was obtained which suggests that site placement did not have a high correlation with the location of springs. This fact applies both to springs that discharge more than 10 liters per second, and ones that discharge less than that amount.

Natural Resource Variable Grouping and Site Correlation Patterns

Site Groupings

One should be made aware of the fact that sites with high potential in certain variables will not always have such potential, and may contain high potential value for other variables. As such, the values for natural resource variable compositions and association patterns for each site need to be studied in a more extensive manner. Correspondence analysis resulted in four site groupings.

Group I, which amount to 10 sites, showed a strong correlation with 5 variable classes (B5, D20, E24, B45, I58), which include steep terrain gradients of more than 15%, latosol-grumosol complex soil types, napalan limestone rocks, and groundwater depth of more than 15 meters with low permeability. Sites within this grouping had a strong correlation with 6 variable classes (F31, C11, H53, A1, A2, C10), which include effective soil depth whose thickness was less than 60 cm, escarpment or fault (*dinding terjal)* landforms, and structural hills, with a height of less than 200 meters and between 200-1500 meters. The combination of variables of this type formed the characteristics of the sites in Group I.

Sites in Group II, which amount to 85 sites, had a strong correlation with 5 variable classes (D17, H53, G44, E23, F29), which includes regosol soil, the distance to the river being less than 500 meters, groundwater depth being between 7-15 meters with high permeability, young volcanic rock, and effective soil depth of more than 90 cm with a coarse texture. The sites in this group had a strong correlation with 7 variable classes (A2, B4, I58, C7, C8, A1, B3), which include a height of between 200-1500 meters and less than 200 meters, a terrain gradient of between 2-15%, as well as that of less than 2%, lower slope landform type, and the slope at the foot of the volcano. The combination from these kinds of variables characterized Group II sites.

Sites within Group III, which amount to 6 sites, has a strong correlation with 5 variable classes (G39, E25, A1, I58, F29), which include groundwater depth of less than 7 meters with a medium permeability, alluvium rock, an altitude of less than 200 meters, the distance to springs being over 1000 meters, and an effective soil depth of more than 90 meters with a coarse soil texture. Sites in this group has a relatively strong correlation with 5 variable classes (B3, D22, H53, C16, H55) which include a terrain gradient of less than 2%, alluvial soil, a distance to rivers being less than 500 meters, and whose landform type is made of natural levees. The combination of these variables characterized Group III sites.

Sites within Group IV, which amount to 117 sites, have a strong correlation with 7 variable classes (B3, C9, D18, E23, I58, F29), which include a terrain gradient of less than 2%, fluvio-volcanic plains, kambisol soil type, an altitude of less than 200 meters, young volcanic rock, a distance to springs measuring more than 1000 meters, and an effective soil depth of more than 90 cm with a coarse texture. Sites in this grouping had a relatively strong correlation with 3 class variables (H53, G39, G43) which includes a distance of less than 500 meters to the river, a groundwater depth of less than 7 meters and between 7-15 meters with medium permeability. The combinations of these variables characterized Group IV sites.

Grouping Environmental Resource Variables

Using the same correspondence method, one may also obtain column profile values for the grouping of natural resource variables, to determine which sites are grouped together in one group and which sites are grouped in other other groups. This analysis has resulted in 4 natural resource groupings, which include group A, group B, group C, and Group D. The value of class variables which have been found in those groups are as follows.

Group A has a terrain gradient of more than 15%, steep / fault landforms, a soil type composed of the latosol-grumosol complex, napalan limestone, a soil potential category of B1aT, an effective soil depth of less than 60 cm with a medium soil texture, a C1 groundwater type with a groundwater depth of more than 15 meters, and a low aquifer permeability.

Group B consists of 12 variable classes, which include an altitude of 200-1500 meters, a terrain gradient of less than 2%, a land form type which consists of both the upper slopes of the volcano as well as lower slopes of the volcano, slopes at the foot of the fluvio-volcano, with an A3aT type land potential with a rough texture, and A3, A4, and B3 groundwater types.

Group C consists of 25 classes of variables, which consists of an altitude less than 200 meters, a terrain gradient between 2-15%; fluvio-volcanic plains; structural hills; kambisol as well as latosol soil types; soil potentials with the types A1aT, A2aT, and C3aT; an effective soil depth of 90 cm with a finely-textured soil; A2, B1, and B2 groundwater types with 2 types of water depth: less than 17 meters, and a depth of between 7-15 meters; medium, large, and very high aquifer permeability; and all of the classes from the distance variables between sites to the rivers and springs.

Group D, whose class variables are grouped in this category are denudational hills landform types, isolated hills (*perbukitan terpisah*), flood plains, natural levees, back swamps, litosol soil, alluvial soil, alluvial soil, alluvium rocks, and breccia.

Now that we have gathered data regarding the variables' combination patterns, it is hoped that we will be use it as a guide to search and find previously undiscovered sites in the future.

Natural Resource Potential Classifications and Site Groupings

The overall value of natural resource variables in the research area which amount to 58 in total can be grouped according to its potential. Six variables which include the terrain gradient, landform type, soil potential, groundwater, distance from site to rivers and to springs were categorized into three potential classifications: high, medium, and low. Two variables which include soil type and rock type were grouped with two potential classifications: high and low; and one variable, altitude, was grouped into two classifications: high and medium. The relative frequency of each site grouping within the different potential class can then be obtained based on these potential classifications. If all of the data from the 9 variables were combined then the following things can be identified as follows:

All Group I sites have low potential in terms of terrain gradient, landforms, soil types, rocks, soil potential, and the distance of the site to springs. Similarly, there is low potential in terms of groundwater. Is it is only for the altitude and distance between the site to river variables that the number composition of sites have a higher potential than those of the medium and low potential.

Group II sites are of high potential in terms of soil type, rocks, soil potential, landform, the distance of the site to the river, and the terrain gradient. Meanwhile, elevation and soil potential are of medium potential. However, the distance of sites to springs variable is of low potential.

Group III sites are of high potential in terms of elevation, landform, soil type, and rocks. In fact nearly all of the sites in this group are of high potential in terms of land potential. Similarly, there are more sites that are of a high potential in terms of terrain gradient and groundwater than there are sites of a medium potential. Only in terms of distance to springs are there more sites with a low potential.

Group IV sites are of high potential in terms of soil potential and groundwater. Similarly, there are more sites with a high potential in terms of altitude, terrain gradient, soil type, rocks, and distance of sites to rivers than there are sites of a medium and low potential in those categories. However, in terms of landform type, and distance of sites to springs, there are more sites with a low potential for this grouping than there are sites with a medium and/or high potential in those categories.

8. Research Suggestions

As a part of the achieved results, research was conducted in regards to finding and updating inventory lists and maps related to site distribution patterns and the relationship between sites and natural resources, which date from before as well as after Indonesia's independence. This research was conducted by trial observations in the field and was conducted in a fairly vast area. This research resulted in several byproducts, which include new inventory lists, particularly of archaeological sites from the Hindu-Buddhist period for the Sleman and Bantul regions. At the very least all of the sites which amount to 218 in total were mapped in a more accurate manner, through coordinates as well as their location against the current administrative districts.

The experience of conducting site research not only resulted in an up to date inventory list, but we have also managed to find flaws which were found in the existing inventory lists thus far. Several flaws ought to be mentioned here, including: (1) flaws in the recording process which do not give proper context; (2) flaws in the registry recording process for archaeological sites and remains; it pays less attention to locational data and there is less attention paid to regular improvements to the registry; (3) the ability of archaeological remains to withstand human and/or natural activities; some may be in need of repair, have gone missing, or may have been moved without proper records; (4) the absence or scarcity of absolute dating; and (5) the lack of attention paid to making accurate distribution maps for archaeological artifacts and sites.

By completing a new inventory list of sites in the Bantul and Sleman regions, it seems that we have successfully provided one of the means in which anyone can use to develop archaeological sites in the future.

9. Conclusion

The analysis results showed that in the research area there were 4 types of relationship patterns between the location of temple sites and the natural resource variables. The relationship variability might possibly describe natural resource utilization patterns (particularly land and water resources) in terms of temple site placement during the Hindu-Buddhist era in the research area. The pattern for Group IV and II were the most commonly found patterns, while Group I and III had patterns which were less common. The Group IV site cluster had more associations with the Group A variable cluster, and Group II site cluster had more associations with the variable clusters of Group B and C. Both site groupings contained natural resources which had more potential in its links with settlement patterns with livelihoods primarily based on wet-rice or paddy-field agriculture, as shown on inscriptions or temple carved reliefs. Meanwhile, the high correlation between Group I's cluster of sites and Group B cluster variable, and that of Group III with Group D, suggests that those sites have natural resource variables which are of less potential or are not suitable with the settled life of village inhabitants which were mainly supported by wet rice agriculture.

The research area has a large potential to be the center of past community settlements, as evidenced by the location of the center of the Islamic Kingdom of Mataram in the Yogyakarta region. The geographic environmental condition of the area does strongly supports for the presence of settlement centers, whether it is villages, whose existence was stated in inscriptions, or larger settlements. That area is capable of supporting a large number of inhabitants whose main livelihood is agriculture, particularly wet rice agriculture. Construction activities and the maintenance of a large number of temples require building materials (stone and brick), and sizeable amounts of human labor and costs.

The study has resulted in data that revealed that a majority of temple sites had more correlation with places that are not too high (less than 200 meters), a flat to gentle sloping terrain gradient (0-2%), and landforms which consist of fluvio-volcanic plains. Such topography provides a large number of conveniences for human mobility in order to conduct a variety of activities (accessibility) in an effort to make ends meet, whereas the results from dominant geo-morphological processes in those areas, which consist of depositional activities and the weathering of natural materials, were extremely beneficial to humans, including the agriculturalists. These processes were generally not harmful, except in certain areas which are subject to the flow of lava when Mount Merapi erupts. The site frequency was also high on landforms which consist of fertile volcanic sediment and good drainage, as the soil was highly porous and its soil permeability was fairly high; the thickness of the solum was more than 90 cm, and as such the land use for agriculture can be conducted with maximum results.

A majority of the temple sites are located in areas whose groundwater depth is not too far from the soil surface (less than 7 meters), with a medium aquifer layer, relatively stable groundwater supply, and clear water. Many sites are located close to streams, which is necessary for daily human needs, including the construction of simple small-scale irrigation. Meanwhile, at the base of the rivers where lava has flown into, there are large chunks of rocks, which can be utilized for temple construction; these temples in reality were established in large numbers. In those places (such as in the Muntilan region) there are currently stone craftsmen who have been able to expand their businesses thanks to the existence of the natural materials like rocks in the bottom of the river that flows nearby. The stone craftsmen approach natural resource locations with the energy minimization principle in order to obtain the greatest possible profit margins. The data also indicated that a majority of sites were actually not located in areas close to springs, even though there are numerous springs that existed with high enough discharge rates. There was no correlation between site location and the spring variable; this may be caused by the availability of sufficiently clean or good quality river water in the past.

With the above statements, it can be briefly concluded that the ecological considerations for the placement of temple sites in the research area were generally in accordance to the principles mentioned in the ancient Indian texts of *Mānasāra-Śilpaśāstra* and *Śilpa Prakaśa*. However in terms of conformity, the considerations as described above were only true for the majority of temple sites in the research area, as the research results also indicate that there is data that indicates that a small number of sites were not located in areas with high land potential. In other words, the sites from Group I are evidence that ecological potential was less of a consideration for some sites, and this clearly is not in accordance with the guidelines presented by Indian texts. This issue will surely raise big questions, and it is possible that these questions may not be answered through research paradigms that use this type of ecological approach models. Other archaeologists will surely be able to conduct an examination of this issue by using other perspectives.

DESCRIPTION OF ENVIRONMENTAL VARIABLE CLASSES

Site Altitude:		**Terrain Gradient:**	
< 0200	Less than 200 m	< 2	Less than 2%
0200-1500	Between 200-1500 m	2-15	Between 2-15%
		>15	More than 15%

Landform:			
Lag	The upper slopes of the volcano	Pd	Denudational Hills
Lbg	Lower slopes of the volcano	Pt	Isolated Hills
Lkfg	Slopes at the foot of the fluvio-volcano.	Dtb	Floodplains
Dfg	Fluvio-volcanic plains	Da	Alluvial plains
Ps	Structural Hills	Ta	Natural Levees
Dts	Escarpment / faults		

Soil type:		**Rock type:**	
Reg	Regosol	Vm	Young Volcanic
Kam	Kambisol	Bgn	Napalan limestone
Lat	Latosol	Al	Alluvium
Lagrul	Kompleks latosol-grumosol	Br	Breccia
Lit	Litosol		
Alu	Aluvial		

Soil Potential:	
A1aT	Effective soil depth more than 90 cm; medium-textured soils; drainage with no flooding; no erosion.
A2aT	Effective soil depth more than 90 cm; fine-textured soils; drainage with no flooding; no erosion.
A3aT	Effective soil depth more than 90 cm; coarse-textured soils; drainage with no flooding; no erosion.
B2aT	Effective soil depth between 60 to 90 cm; fine-textured soils; drainage with no flooding; no erosion.
C1aT	Effective soil depth between 60 to 90 cm; medium-textured soils; drainage with no flooding; no erosion.
C3aT	Effective soil depth between 60 to 90 cm; coarse-textured soils; drainage with no flooding; no erosion.

Groundwater:	
A2	Groundwater depth less than 7 meters; medium permeability
A3	Groundwater depth less than 7 meters; high permeability
A4	Groundwater depth less than 7 meters; very high permeability
B1	Groundwater depth between 7 to 15 meters; low permeability
B2	Groundwater depth between 7 to 15 meters; medium permeability
B3	Groundwater depth between 7 to 15 meters; high permeability
C1	Groundwater depth more than 15 meters; low permeability

Nearest Site Distance To Rivers:		**Distance Between Sites to Springs:**	
< 0500	Less than 500 m	< 0500	Less than 500 m
0500-1000	Between 500-1000 m	0500 - 1000	Between 500-1000 m
> 1000	More than 1000 m	> 1000	More than 1000 m

Bibliography

Acharya, Prasanna Kumar
1933 *Architecture of Mānasāra*. London: Oxford University Press.

Binford, Lewis R.
1972. *An Archaeological Perspective*. New York: Seminar Press.

Bintarto, R. and Surastopo Hadisumarno
1979. *Metode Analisis Geografi.* Jakarta: Lembaga Penelitian, Pendidikan dan Penerangan Ekonomi dan Sosial (LP3E).

Boner, Alice, dan Sadasiva Rath Sarma
1966. *Śilpaprakaśa*. Leiden: E. J. Brill.

Clarke, David L.
1977. *Spatial Archaeology*. London: Academic Press.

Cox, Kevin R.
1972. *Man, Location, and Behavior*. New York: John Wiley.

Dunnell, Robert C. dan William S. Dancey
1983. "The Siteless Survey: A Regional Scale Data Collection Strategy." *In* Schiffer, M. B. (ed.), *Advances in Archaeological Method and Theory* 6: 267-287.

Greenacre, M. J.
1984. *Theory and Applications of Correspondence Analysis.* London: Academic Press.

Hardesty, Donald L.
1980. "The Use of General Ecological Principles in Archaeology." *In* Schiffer, M. B. (ed.), *Advances in Archaeological Method and Theory* 3: 157-187.

Hodder, Ian, and Clive Orton
1976. *Spatial Analysis in Archaeology*. Cambridge: Cambridge University Press.

Hodder, Ian
1977. "Some New Directions in the Spatial Analysis of Archaeological Data at the Regional Scale." *In* Clarke, D. L. (ed.), *Spatial Archaeology*: 223-351.

Jambu, Michel
1991. *Exploratory and Multivariate Data Analysis*. London: Academic Press.

Kirch, Patrick V.
1980. "The Archaeological Study of Adaptation: Theoretical and Methodological Issues." *In* Schiffer, M. B. (ed.), *Advances in Archaeological Method and Theory* 3: 101-156.

Kramsrich, Stella
1946. *The Hindu Temple.* Calcutta: University of Calcutta.

Lebart, Ludovic, Alain Morineau, and Kenneth M. Warwick
1984. *Multivariate Descriptive Statistical Analysis: Correspondence Analysis and Related Techniques for Large Matrices*. New York: John Wiley & Sons.

Purbohadiwijoyo, M. M.
1967. "Hydrogeology of Strato-volcanoes: A Geomorphic Approach." *Memoires I. A. H. Congress 1965* VII: 293-298. Hannover.

Read, Dwight W.
1975. "Regional Sampling." *In* Mueller, James W. (ed.), *Sampling in Archaeology*: 46-50. Tucson, Arizona: The University of Arizona Press.

Schiffer, Michael B.
1972. "Archaeological Context and Systemic Context." *American Antiquity* 37: 156-165.

Soekmono
1974. "Candi, Fungsi, dan Pengertiannya." Unpublished dissertation, Universitas Indonesia. Jakarta.

Sutikno *et al.*
1988. "Laporan Penelitian Potensi Airtanah di Lereng Gunungapi Merapi Tahap I (Dikaitkan Dengan Arkeologi)." Yogyakarta: Fakultas Geografi Universitas Gadjah Mada dan Badan Koordinasi Survey dan Pemetaan Nasional.

Taylor, Walter W.
1973. *A Study of Archaeology*. Fourth Edition. London: Feffer & Simons.

Thomas, David H.
1979. *Archaeology*. New York: Holt, Rinehart, and Winston.

Verstappen, H. Th.
1983. *Applied Geomorphology: Geomorphological Surveys for Environmental Development*. Netherlands: International Institute for Aerial Surveys and Earth Science (ITC).

Watson, Patty Jo, Le Blanc, dan Charles Redman
1971. *Explanation in Archaeology: An Explicitly Scientific Approach*. New York: Columbia University Press.