Integration System of Archaeological and Geographical Information for Planning in Historical Regions

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ABSTRACT

This study aims to construct the GIS for supporting the planning process and archaeological analysis in the historical regions by integrating geographical data and archaeological data on the sites with ruins and remains in various period from ancient through medieval which had been buried and was recently excavated in geologic layers and mounds. First, for understanding the trends of environmental condition the excavated sites, we analyze the relationship between the site location and the condition of geography and natural environment by using the constructed system.

Secondary, we develop the system to make it possible to browse and operate the information on the GIS through the internet. This web GIS constructed by us supports sharing the information on planning for preservation of historical sites among city planners, archaeologists and citizens, and serve as a tool for the collaboration and the coordination of urban development and historical preservation. Finally, as the application with the GIS, we show the results of case studies and point out the merits and effects about usage of the GIS for archaeological analysis as well as learning the local history.

1 INTRODUCTION

1.1 **Background**

It has been one of the most important issues for city planning and urban development how to preserve the historical sites like ancient tumulus, colony ruins, kitchen middens, and remnants of ancient architectures in the historical regions in Japan as well as in other countries. Sometimes, many of these historical sites are recognized as previous cultural assets which are worth being preserved as they are or restored as they were.

In 1970's, Japan had experienced the movement that appeals the necessity of preserving the historical townscapes and environments all over the country like traditional architectures and farmhouses in the old towns and villages. After the movement, Japanese government changed its policy and has been positively coping with the problems for the preservation of historical environment.

Following the policy of Japanese government, the Law for Protection of Cultural Properties specifies the obligation of the landowners who would implement the new development of the land to do field survey on remains under the ground prior to the construction.

Recently, in the historical regions of Japan, the most severe problem for land developers who are going to pioneer the natural or farm land is the cost and time for the pre-survey done just before the construction work, and moreover that they can not accurately estimate the cost and time before the beginning of construction because the underground condition cannot be visible and predictive. And fortunately or unfortunately they sometimes found valuable ruins which they had not expected before the site planning. The evaluation of the found ruins influences the development project of the site. The projects should be often given up if the ruins found in the sites are identified as worth being preserved.

In a word, in the historical regions, we cannot predict what are buried under the ground and the excavation of ruins is a confounding nuisance for developers and landowners. In this point, it is needed to create tools for supporting the process of planning at the sites in the historical regions from the view of archaeology as well as geography.

On the other hand, the archives and data of the found ruins, remains and cultural assets are not well maintained and should be arranged to be useful for learning by citizens. To promote the movement for preservation of ruins and historical environment in the historical regions, we should make arrangement of these archaeological documents and data as a set of useful and comprehensive information on local history and culture, and share the information to help citizens understanding the historical context of the region over the centuries. Confronting these issues, we started our research project for constructing the web GIS by integrating archaeological and geographical data (Nakano et al. 1997).

1.2 **Objectives**

1.2.1 *Creating GIS and Database on Archaeological Sites*

This study aims to create the web GIS by making arrangement of the data on the archeological sites and cultural assets and integrating the database with the geographical information. For the arrangement, we categorize the archaeological remains and ruins by the age (period) and type such as mounded tomb (see figure 1), grave and settlement. This integrating web GIS will be open to public through the internet for sharing the information on local history and archaeology among citizens and various concerning experts. In addition, the GIS will be developed as a tool to be manipulated for supporting the process of preservation planning as well as city planning.

1.2.2 *Analyzing Archaeological Sites and Exploring Ancient Local Context with GIS*

For utilizing the constructed web GIS from the academic view, we try to analyze a group of archaeological sites through the case studies by operating the database and analyzing the geographical condition.

In general, the archaeological sites in the historical region consist of layers (stratums) which overlay age after age. For understanding the ancient history of the region, we have to identify the layer by period and realize the geographical and social

condition in the region of each era by drawing an ancient topography including the location of all the excavated sites as existed in the era. Especially for the archaeology, it is one of the most curious academic issues to identify the area of the territory occupied or governed by each of the ancient settlements in the region. As far as this issue, we try to propose the method to support the archaeological analysis for identifying the territory area of each settlement by spatial analysis on the location data of the sites such as settlement and mounded tomb as the examples of utilizing the GIS and the database we created.

Through the case studies on the target area, we show some ideas on possible usage of the web GIS.

2 METHOD

2.1 **Target Area**

We choose the Itoshima Region of Fukuoka Prefecture in Japan as the target historical region for the case studies. Itoshima Region is one of the most famous historical areas in the western part of Japan. However, recently there are a lot of urban development projects and the urbanized areas are expanding in consequence of the growth of Fukuoka City and the sprawl of its metropolitan region. The area of the Region is 400 square kilometers (twenty kilometers square) including the sea (see figure 4).

In addition, Kyushu University is planning to construct a new campus in the center of the Itoshima Region. The new campus area is 275 hectares and holds many of ancient mounded tombs, remains of iron-working site (see figure 2) and settlement which were excavated for these ten years after starting the new campus project. The new remains are being found one after one as the results of field survey, which means that there existed some of ancient settlements on the new campus area.

According to our research, there are approximately 2,000 sites found in Itoshima Region until now. The local governments and citizens are looking for the way to preserve the historical environment under the pressure to urbanize the area (Tabira et al. 2001). In the case studies, we focus on the typical area where many of ancient sites are concentrated in the southeastern part of the region, and test the application for analyzing the ancient geographical and social context by the method of grouping the ancient sites.

2.2 **Integration of Geographical and Archaeological Database**

For constructing the GIS, we form two types of original topographical model of the target area; one is mesh data (500 meter square), and the other one is more detailed data of contour polygon. We visualize the ground surface model in reality by mapping the aerial photograph data on the three-dimensional topographic model.

Figure 1: **Circular-shaped Mounded Tomb**

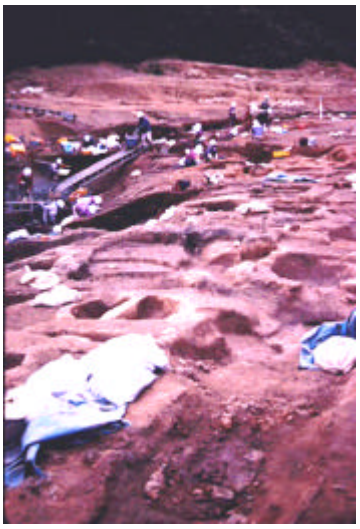

Figure 2: **Iron-working Site**

The database on the sites is constructed by categorizing by period and type. After the arrangement of the site database, we link the database with the GIS and develop the system by using the software (Map Object and Visual Basic) for operating and visualizing the database through the web.

2.3 **Construction of web GIS**

For the citizen involvement in the planning process, the citizens have to understand the historical context and geography of the target area through the academic survey and archaeological analysis. For understanding the target area, we try to construct the web GIS for visualizing and browsing the information on the sites such as location and other properties on the digital maps through the web. The web GIS enables users to make easy access to the database and to look into the site information (see figure 3).

In the historical regions, it is a nuisance to have to maintain and renew the database on a great deal of excavated remains and found cultural assets. In these regions, the remains are being excavated and the news on the archaeological discoveries is announced almost every year. In this point, we aim to develop our web GIS function as a tool to maintain and update the site database as well as to input the new data through the internet by remote operation more easily, and it enables people to share the renewed information. The web GIS is expected to support the academic analysis as well as learning the local history.

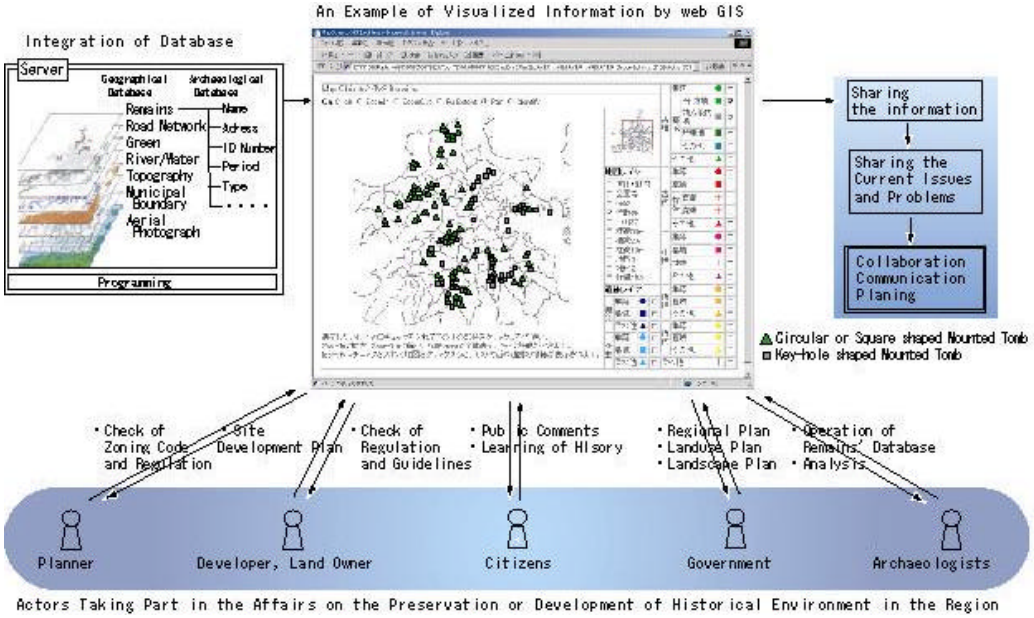

Figure 3: **Image of Configuration and Usage of web GIS**

3 CASE STUDIES AND ANALYSIS

3.1 **Application for Analysis on Geographical Condition of Sites**

3.1.1 *Purposes of Case Studies*

We create and test the application to make use of the GIS for analyzing the characteristic points about the layout and location arrangement of the sites from the view of he relation of natural elements such as rivers, hills, mountains and valleys.

In addition, we try to prove the archaeological hypothesis on the formation of the territory area occupied by each ancient community by the method of exploring the geographical and social condition with the spatial analysis on the relation of ancient sites in the GIS. One of the most curious topics for the archaeologists in Japan is the size and location of the territories occupied by the ancient agricultural communities and how these different communities kept the balance of political power among them (Matsuura et al. 2002).

3.1.2 *Target Area*

As the target area for the case studies, we choose the area, where the sites of Mikumo, Ihara, Hirabaru, Sites are densely located in the field of approximately eight kilometer square (see figure 4). The target area includes three rivers running from south to north and long-shaped hills among the rivers(see figure 5). There are a lot of ancient sites such as settlements and circular-shaped mounded tombs found in the hills and plain field among the rivers.

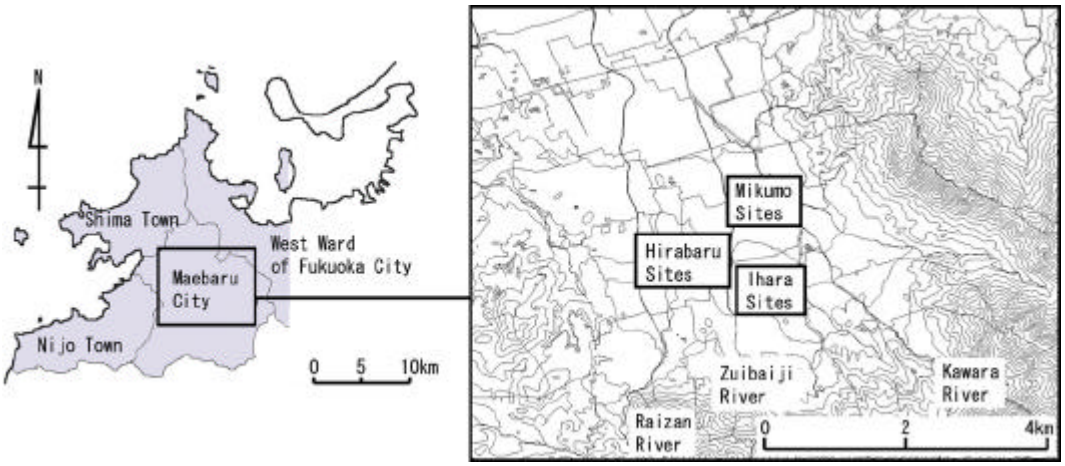

Figure 4: **Map of Itoshima Region (Left) and Map of Target Area for Case Studies**

On the mountainsides in the east of the area, there are masses of ancient mounded tombs (see table 1).

3.1.3 *Trend of Location of Ancient Settlement*

First, we analyze the geographical condition of the location of the settlements from the view of the relation between settlement site and the nearest river with buffering on the baselines of the rivers. The result shows that all of the found ancient settlement sites are concentrated 100 through 400 meter distant from the nearest river(see figure 6). Seeing the result, we can conjecture the strong relation between agricultural settlement and the river in ancient daily life even if the line and form of the rivers was changed gradually.

3.1.4 *Trend of Geographical Condition of Ancient Sites*

Secondary, as the results of the statistical analysis on the geographical condition of the ancient sites, the trend and characteristic point of each type of sites were shown as follows;

(1) Almost all of the mounded tombs are located 50 through 150 meters high above the sea level, and almost all the settlement sites are located on the lower field at less than fifty meter high above the sea level(see figure 7).

Table 1: **Number of Sites Located in Target Area**

		Kofun Period			
	Legend	Early Stage	Middle Stage	Final Stage	Total
Key-hole Shaped Mounded Tomb		8	3	6	17
Square Shaped Mounded Tomb		1	0	1	2
Circular Shaped Mounded Tomb		7	13	124	144
Settlement		6	4	6	16

Figure 5: **Three-dimensional Topographic Model of Target Area**

(2) The environmental condition of circular-shaped mounded tombs is unique and different from the condition of other types of mounded tombs, and many of them are located on the mountainsides at higher level. Many of the clusters of small mounded tombs (family graves) were built in the final stage of the Tumulus Period, and it means that it might be a custom of the period to build the tombs on the mountainsides at the higher level for the local worship.

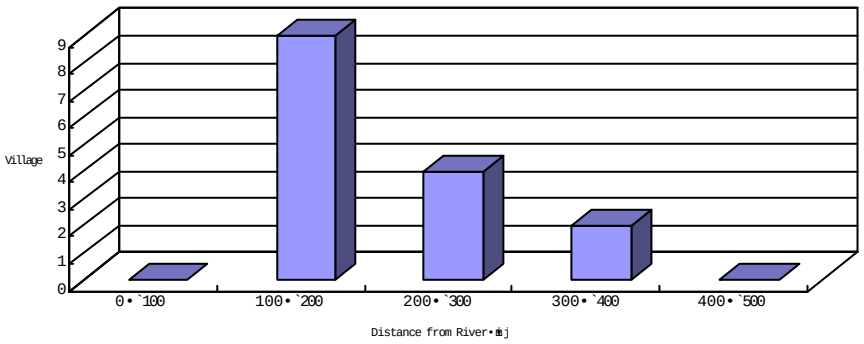

Figure 6: **Distances between Settlement Site and Nearest River**

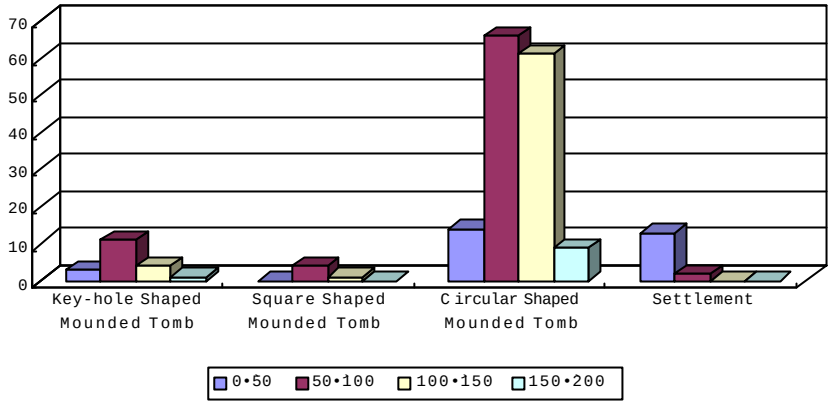

Figure 7: **Types of Site and Ground Level of Site Location**

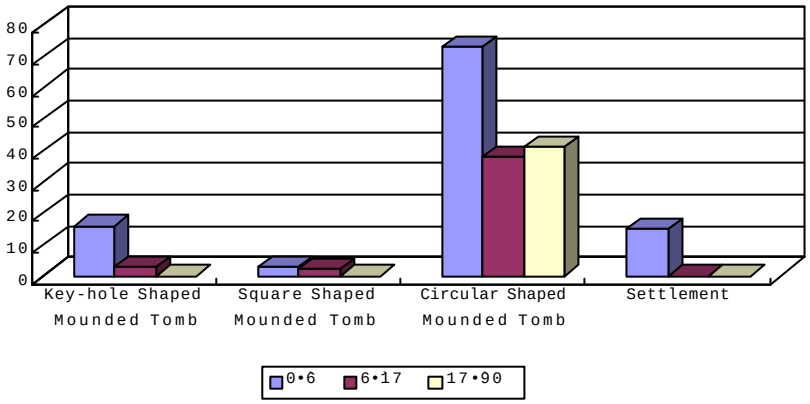

Figure 8: **Type of Site and Angle of Ground Inclination of Site Location**

(3) All of the settlement sites and almost all of the keyhole-shaped mounded tombs and square-shaped mounded tombs were located in the flat fields. On the contrary, only the half of the round-shaped mounded tombs was located in the flat fields, and the rest were located on the hills or mountains (see figure 8).

These results of statistic analysis show that the environmental condition of the round-shaped mounded tombs is clearly different from the other types of sites (see figure 7 and 8).

3.2 **Application for Proving Archaeological Hypothesis on Ancient Local Territory**

3.2.1 *Analysis on Visibility Condition of Sites*

By using the three-dimensional topographic model of the whole target area with the location data of the ancient sites of mounded tombs and settlements, we analyze the relationship between any two sites in terms of the visibility condition of the sites, and try

to organize the sites into some sets based on the analysis. For the definition of ancient territories, we make an application to define a set of relative sites by calculating the visibility between a tomb site and a settlement site of the same age automatically in the three-dimensional topographic model of the GIS. The method is based on the assumption that each of the mounded tombs was an object of veneration and should be visible from the settlement where the people building it were living.

The process to organize the sites with mutual relationship and define a set of sites is as follows;

(1) Choose any pair of settlement site and mounded tomb site, and check the visibility between these two sites on the 3D topographic model.
(2) Form a set of village sites and mounded tomb sites linked with the settlement sites in terms of visibility from each other.

As the results of the analysis on visibility in the layer of each of three stages (early: AD300-400, middle: AD400-500 and final: AD500-600) of the Tumulus Period (see figure 9-11), we can organize the sites and form some sets of settlements and mounded tombs. In other word, by the method, the sphere where a set of sites is located is recognized as a social territory occupied by the settlements of the age. We compare the results with the archaeological hypothesis on the local territories occupied by the ancient agricultural settlements in the period (AD 300-600) and verify that they are similar to each other. It means that the results of the analysis are a proof of the hypothesis based on the field survey of remains.

3.2.2 *Hypothesis on Formation of Ancient Local Territories*

Comparing with the location of the sets of the sites in each stage of the Tumulus Period, we can see the movement of the territories of the agricultural settlements. In the early stage, the territories were located in the upper side (north side) and the formation of the sets of sites was gradually shifting from north to south (see figure 9-11).

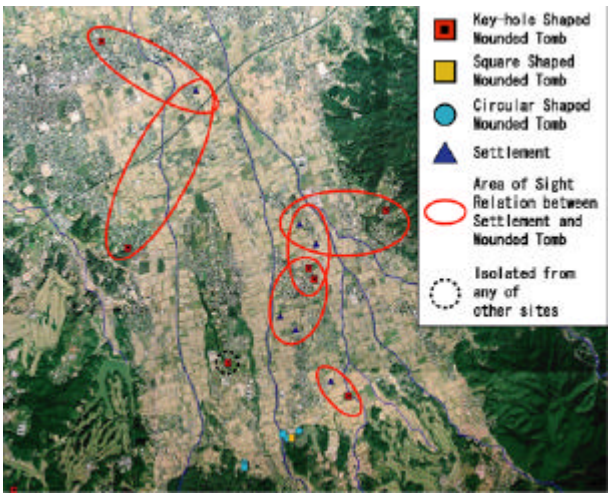

Figure 9: **Sets of Settlement and Tomb Sites (Early Stage of Tumulus Period)**

It means the agricultural settlements moved from the lower field toward upper field and hillside area along the rivers. The results show the long-term movement of the formation of territories by agricultural settlement.

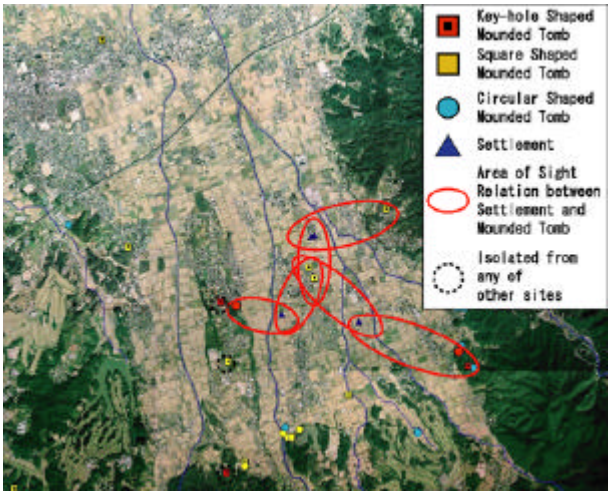

Figure 10: **Sets of Settlement and Tomb Sites (Middle Stage of Tumulus Period)**

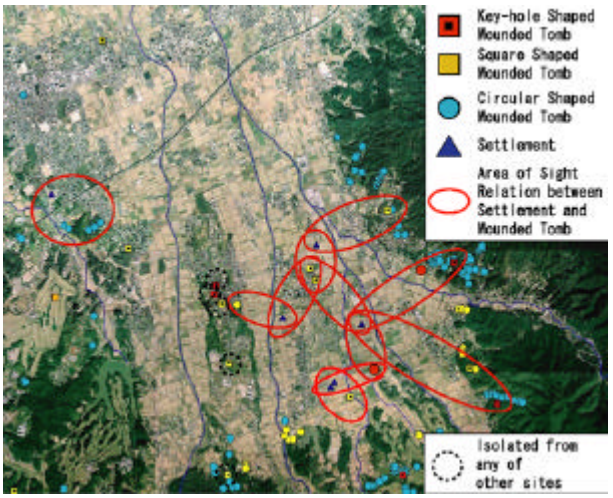

Figure 11: **Sets of Settlement and Tomb Sites (Final Stage of Tumulus Period)**

We can provide the planners and citizens with the archaeological information through the analysis with GIS, and help them understanding the local context of the ancient periods in the planning process for the preservation of the historical area including these archaeological sites.

3.3 **Application for Identifying the Area of Undiscovered Sites**

3.3.1 *Trend of Visibility Condition of Settlement and Tomb*

This case study is done for testing the method to help finding the undiscovered sites. At first, for defining the decisive factors to identify the site area, we analyze the trend on visibility condition of viewing from a settlement site to the visible mounded tomb sites by calculating the distance and the angle of view. The results are as follows;

(1) The high percentage (86%) of the distances between a settlement site and a visible tomb is within the middle-range (340 meters through 2,100 meters).

(2) We expected that the angle of view from a settlement to a tomb should be the angle of elevation because the mounded tombs are the objects for worship. However, it is not always the angle of elevation, and the maximum of the angle of view is less than 3.5 degrees, and the average is 1.14 degree, which is lower than we expected.

The results show that the average visibility condition of viewing from a settlement site to visible mounded tombs is middle-range distance and low angle of elevation.

3.3.2 *Identification of Undiscovered Settlement Area Based on Trend Analysis*

By making use of the above results about the condition relative to the location of sites, we try to identify the area where the undiscovered settlements are to be possibly located. As one of the results of the analysis of Chapter 3.2.1, we find out five mounded tombs which were invisible from any of the settlement sites. On assumption that the tombs should be the objects of worship and built in the visible area, we expect that there might exist one or more undiscovered settlement sites near the tombs and some of the archaeologists point out the possibility of the existence of ancient settlement somewhere in the area.

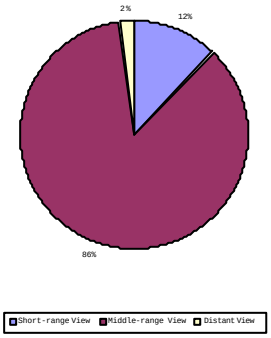

Figure 12: **Range of Distance between Settlement Site and Tomb**

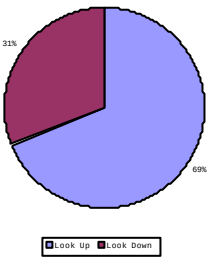

Figure 13: **Ratio of Viewing Angle from Settlement to Tomb**

The method for identifying the area of undiscovered settlement sites consists of the procedures to specify the possible area based on the decisive factors and condition cleared in the above analysis. By overlaying the area specified in the GIS by the factors on the location of settlement sites, we narrow the identified area (see figure 14). For example, the factors are;

(1) The settlements are located in the area between 100 and 400 meter far from the river.

(2) The angle of view from the settlement to a visible mounded tomb is less than 3.5 degrees.

We overlay the linear area figured out by Factor (1) and the area visible from each of the five tombs following Factor (2), and then can identify the area on the map of GIS (see figure 14). This application in the GIS is expected to support the future excavation and field survey on archaeology.

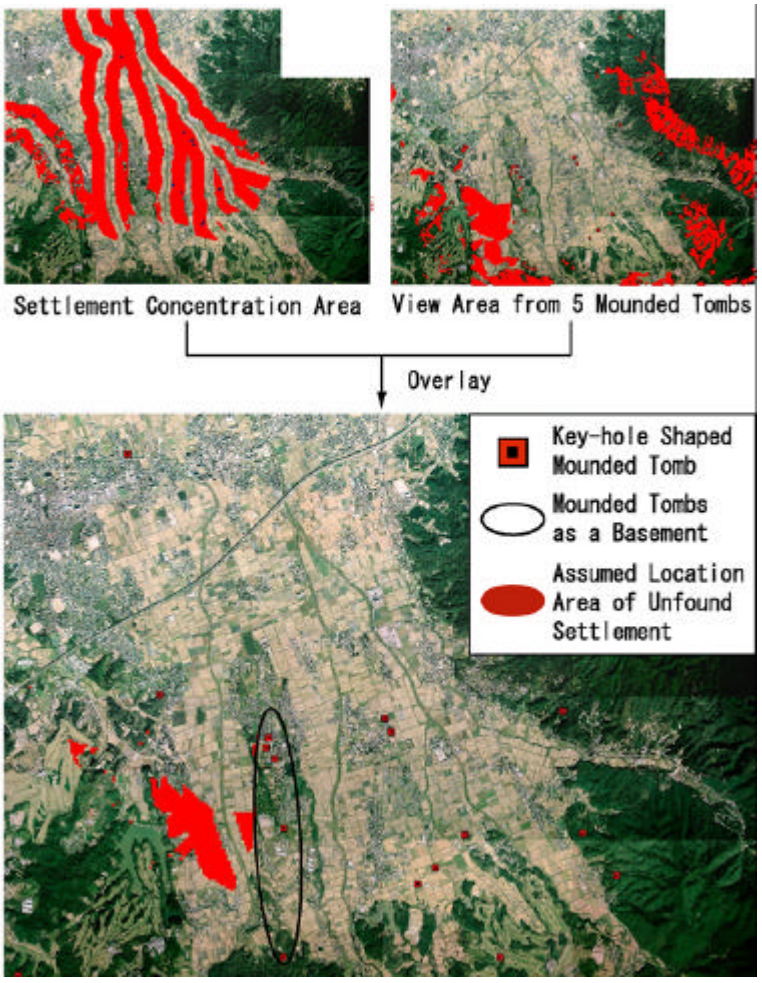

Figure 14: **Identification of Area of Undiscovered Settlement Sites by Overlaying Factors.**

4 CONCLUSIONS

In this study, we are able to show the advantage of the GIS of integrating the geographical and archaeological data from the view of academic analysis as well as learning on local history. The GIS enables planners, archaeologists and citizens to look over the historical area from the various aspects. It will serve as what is called 'four-dimensional GIS" for sharing the information on the local history and geography and supporting the planning process to preserve the historical environment in the scale of region or district.

In addition, as shown in the case studies, the GIS can be a tool to enable us to prove the archaeological hypothesis on the ancient social condition and physical environment which might be much difficult to be visualized without the system.

We are preparing to make this web GIS open to the public near future, and will make use of the web GIS by creating the application for the preservation of the historical and cultural assets in the historical regions.

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