

A GIS Application for the study on water supply and draining system in the ancient capital cities in Japan

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Abstract: The ancient capital cities in Japan had straight streets running east to west and north to south. These streets divided the city into a checkerboard pattern of regular blocks.

There was a drainage ditch on each side of the street. In cities, these ditches were essential for the daily life. The Heijo capital was the principal capital in the eighth century AD. The Nara National Cultural Properties Research Institute started the archaeological and historical investigations into the Heijo capital in 1955. There are many data of drainage ditches at the present time. We must utilize these data to study the ancient cities.

Based on the above, this paper aims to introduce a current status of our project. At present, we are carrying out preparation of basic data and experiments with model areas.

Key words: GIS, ancient city, water supply and drainage system, Heijo capital, TIN, draining ditch.

Introduction

The ancient capital cities in Japan were formed based on the cultures of East Asia. These cities were the center of Japanese political, economic, ritual, and cultural life. Straight streets running east and west and north and south divided the city into a checkerboard pattern of regular blocks.

Such cities were constructed in the Kinki region of Japan (fig.1). Representative cities are Fujiwara capital (684-710 A.D.), Heijo capital (710-784 A.D., situated in the current city of Nara), Nagaoka capital (784-794 A.D.) and Heian capital (794 A.D.-, situated in the current city of Kyoto).

A street in any of these cities had a ditch on each side of the street. The ditches worked as a drainage through which runoff rain water and contaminated household water would flow. In cities, these drainage channels were essential for the city to function as a place for people to live in.

It is also notable that various archeological finds, such as wooden tablets, wooden implements, pottery, clay objects, roof tiles and natural features have been found in or near these ditches.

The ditches are being studied from various viewpoints. Studies include analysis of written materials by historians, examination by historical geologists, and excavation by archaeologists. The

information obtained from excavations is particularly significant in that it increases our knowledge of such cities.

The enormity of excavation records has made it difficult to utilize a large amount of data obtained by means of the conventional analytical methods. It is now essential to introduce a new method that will integrate the accumulated research data.

It is possible to reconstruct a draining system based on data regarding both the plan position and the altitude from excavation. It is also possible to compare the overall system of the city that may appear based on a macroscopic perspective and the actual models that may be created based on individual examples.

To that end, a means that enables integration and analysis of the accumulated spatial information is necessary. A geographic information system (GIS) would appear to meet these needs.

Based on the above, research is currently underway with a main focus on the drainage ditches of Heijo Capital (fig.2), the most famous city during the Nara period (710-784A.D.).

The goals of the research are as follows:

1. Collect the yields from excavations conducted to date based on a uniform standard and use them as a basis for future research.

2. Build a spatial database using a GIS, and clarify the city plans and actual designs of water supply and drainage systems of ancient cities.
3. Contribute to research in various disciplines through the organization and publication of the collected data.

While the research is still underway, we would nonetheless appreciate the opportunity to present an interim report and exchange opinions with various persons.

We believe that interdisciplinary collaboration is possible with regard to this research not only with experts in archeology, history and historical geology, but also with various other scientists, including experts in information science, urban sociology, civil engineering, historical metrology and hydrology.

Direction of research

This research is being carried out in a three-pronged direction.

(1) Development of water supply and drainage system analysis system

A system that accepts data input, carries out interpolation-based generation of three-dimensional data, and analyzes water flow must be developed. AutoCADMap2000 and IDRISI32 will be used. In addition, because a TIN model needs to be created, AutoCAD Land Development Desktop will be introduced.

(2) Collection of basic data relating to the water supply and drainage system of Heijo capital

Plan and altitude data on the drainage ditch within the city will be extracted from the results of excavation. Adjustments are made to the data in order to incorporate it into the analysis system. A digital elevation model (DEM) will be prepared from the existing 1/1000 scale Heijo capital topographical map created by the National Research Institute for Cultural Properties, so that it may serve as a basic topographical map.

(3) Comparison of water supply and drainage systems in ancient cities in Japan and East Asia

Information will be collected regarding cities in East Asia, particularly Japan, Chinese Continent and Korean Peninsula, to study the well-planned nature of the ancient cities from the perspective of water supply and drainage systems.

Current status

Preparation of basic data on a drainage ditch.

153 pieces of basic data on a drainage ditch has been successfully collected from data derived from an investigation conducted by the National Research Institute for Cultural Properties. Data is being extracted from data obtained from an investigation conducted by the Nara City Board of Education. Data possessed by other organizations will be reviewed as well. The data is stored in a computer as it is collected (fig.3).

In order to analyze the entire water system in the Heijo Capital,

data will be collected regarding the top and bottom edges of both banks and the deepest points of the drainage ditches extracted at given intervals. Observation of some areas of the cross-section of the stratum provide important information that provides clues regarding changes to the ditches because it sheds some light on the burying and remodeling of them.

The incorporation of such information is given high priority.

Experiments with model areas

In developing the analysis system, two areas were chosen as model areas from among the collected drainage ditches data, and the contents of the necessary data and the format thereof are being reviewed and input support modules are being developed while the model areas are used for specific input. Many of the records from excavations indicate the altitude at any given plan point, so we are considering the creation of models using TIN for input purposes.

An experimental model of SD6400, a drainage ditch located on the west side of Eastern First Avenue (Higashi Ichibo-ji), will be presented here (fig.4-5).

Based on the models, we plan to study the direction of the water flow, confluence and forking, and changes in the flow amount due to precipitation.

Preparation of DEM

The 1/1000 scale topographical map that serves as the basis for the Heijo Capital DEM contains many symbols, and some of the contour lines are missing. Therefore, contour lines are manually extracted and the missing areas are supplemented. This map is read in using a scanner, and converted into vector data after skeletonization (fig.6). It is finally converted into mesh data. This method has already been used in regard to archaeological sites in Japan. The extraction of contour lines has been completed, and we are now determining the method by which to digitize the data.

We believe that such data that has been collected and accumulated is useful not only in archaeological research but also in research and applications in various many other fields of study. The results of our research will be published in the form of books and data compilations.

In addition, we plan to advance our research regarding the development plan and the actual construction of the streets based on the data accumulated through this research.

Conclusion

This project has just begun. We would appreciate advice and guidance from various experts. Excavations of ancient cities are progressing on a daily basis, and new finds are continually being uncovered. We hope to pursue our research while trying to find a way to use these finds. We also hope that this system can comprise a system able to incorporate new excavation data and reflect them in the research.

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Legends

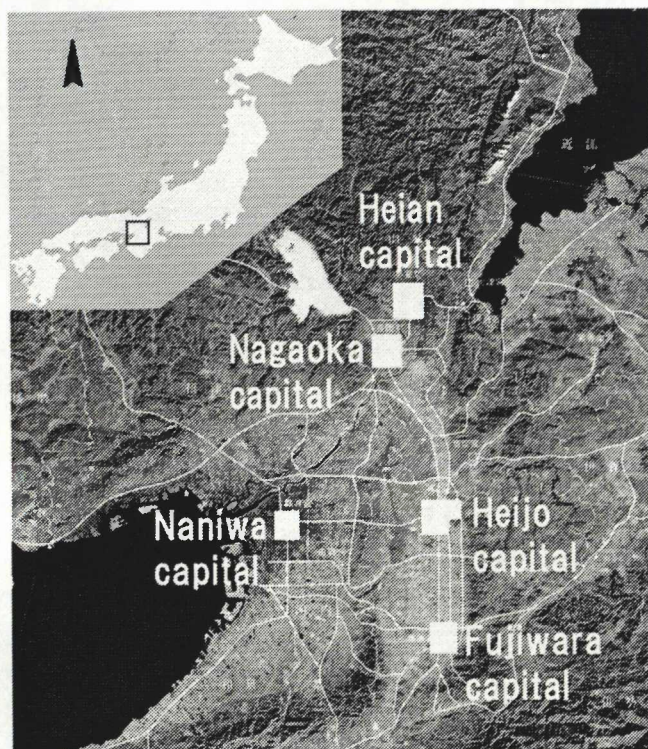


Figure 1. The ancient capital cities in Japan.

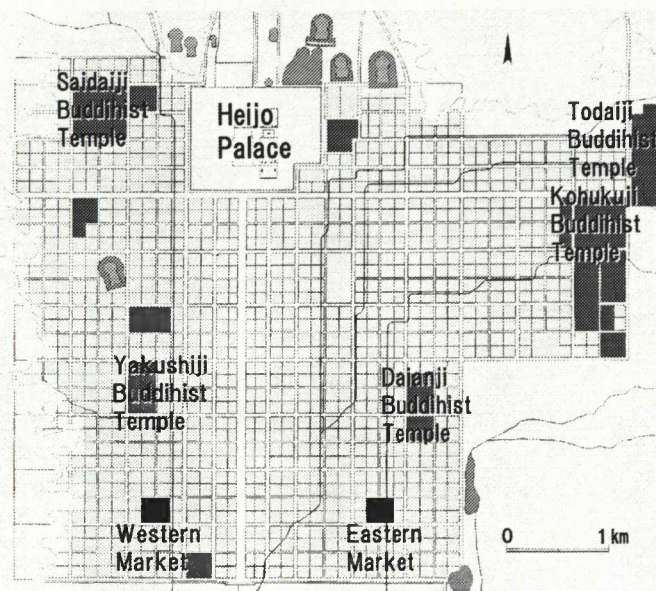


Figure 2. Plan of Heijo capital.

References

Ozawa, T., 1997. Fujiwara: The Establishment of an Ancient City. Quarterly of Archaeological Studies, vol.44-3:52-71. (Printed in Japanese)

Kaneda, A., 2000. A study of water-use systems in ancient cities by use of GIS. Papers and proceedings of the Geographic Information Systems Association, vol.9:429-432. (Printed in Japanese)

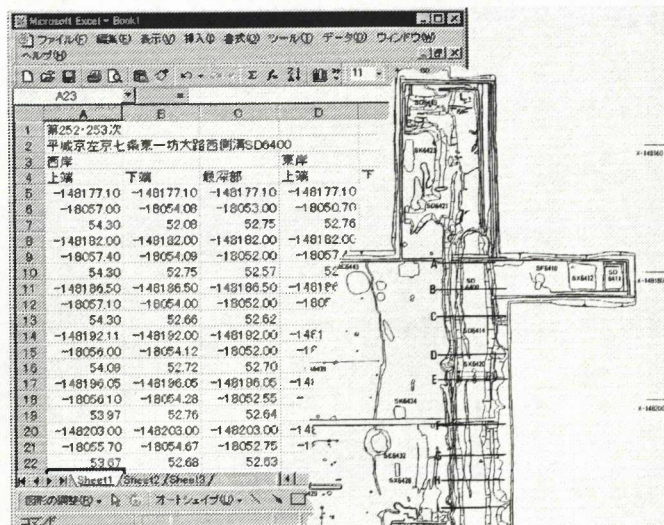


Figure 3. Collection of basic data on a draining ditch.

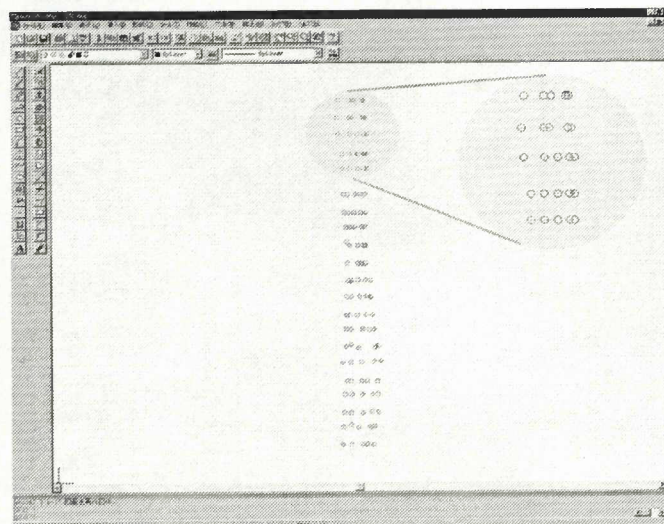


Figure 4. Showing data points as to a draining ditch.

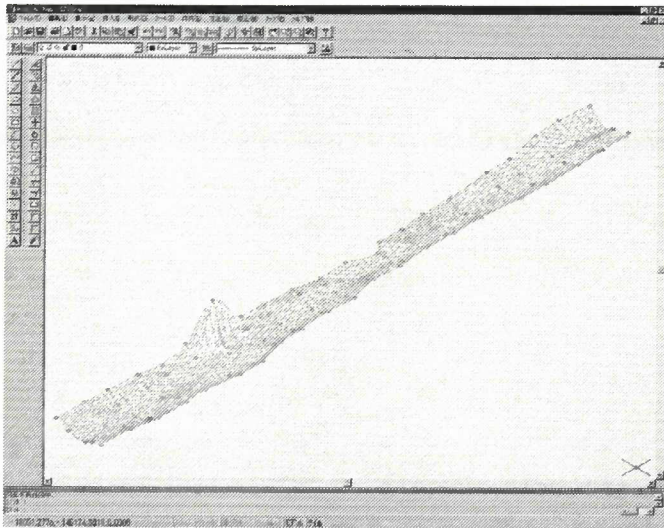


Figure 5. TIN modeling of SD6400.

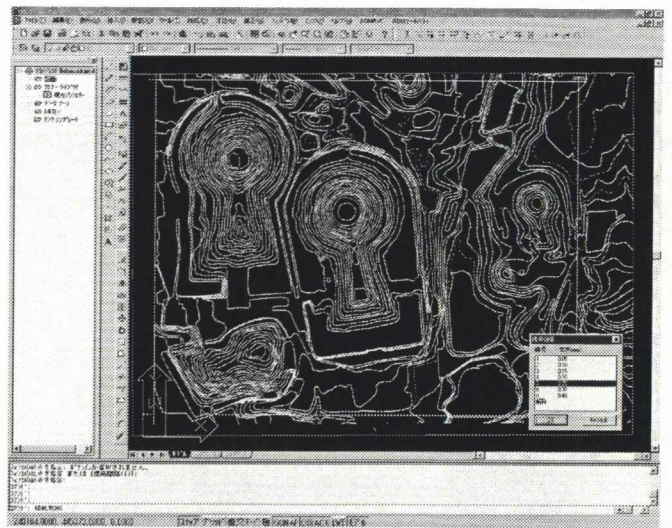


Figure 6. Preparation of DEM