

## APPLICATION OF SATELLITE REMOTE SENSING TECHNIQUES TO ANCIENT SITE MAPPING: A CASE STUDY OF THE MIDDLE EUPHRATES AREA, SYRIA

Tomoya Goto<sup>a</sup>, Hitoshi Hasegawa<sup>b</sup> and Ken Matsumoto<sup>c</sup>

<sup>a</sup> Postgraduate student, Graduate School of Human Sciences, Kokushikan University, 4-28-1 Setagaya, Setagaya-ku, Tokyo 154-8515, Japan - tomoya510@gmail.com

<sup>b</sup> Department of Geography and Environmental Studies, Kokushikan University, 4-28-1 Setagaya, Setagaya-ku, Tokyo 154-8515, Japan - hasegawa@kokushikan.ac.jp

<sup>c</sup> The Institute for Cultural Studies of Ancient IRAQ, Kokushikan University, 1-1-1 Hirohakama, Machida-shi, Tokyo 195-8550, Japan - matumoto@kokushikan.ac.jp

**KEY WORDS:** Satellite remote sensing, Cartography, Basemap, Database, Tell Type Ancient sites, Syria

### ABSTRACT:

Joint Scientific investigation of Japan and Syria started in the Bishri Mountains in the Middle Euphrates Area of Syria in 2005. This area is considered as one of the primary homelands of ancient civilization of Assyrians and Babylonians. The purpose of this project is to clarify the natural and cultural changes of this area based on integrated research methods. We have been participating in this investigation as a geography team.

We have made base maps and ancient site distribution maps of Middle Euphrates area. The main place of the investigation is the "Tell-type" ancient site that is called Tell Ghanem al-Ali which began excavation in 2007. The Tell-type ancient site is known as the hill-shape settlement ruins made from mud bricks in the west Asian region. Although it was necessary to use detailed maps for the investigation, it was difficult to obtain large-scale topographic maps and aerial photographs in this area. In such case, it is effective to use satellite remote sensing techniques to make maps.

We would like to report here a case in which mapping and investigation was made on ancient site distribution in the Middle Euphrates area based on satellite data. We used middle resolution satellite data from ALOS to make base maps and ancient site distribution maps. We also used high resolution satellite data from QuickBird to make detailed maps. Furthermore, we used CORONA, LANDSAT and ASTER for the extraction of land cover change in this area. In addition, we also used the ALOS PRISM Digital Surface Model based on digital photogrammetry to make contour lines.

Through the filed survey based on these maps, we discovered ancient sites which were not recorded before. The application of satellite remote sensing techniques to ancient site mapping is thus a very useful approach to areas where detailed are not available.

### 1. INTRODUCTION

This paper describes mapping of ancient sites using basic satellite remote sensing techniques, which has been conducted as a joint scientific research project between Japan and Syria since 2005.

The Bishri Mountains (Fig. 1), which lie in the Middle Euphrates Area of Syria, are believed to have been a homeland of ancient Assyrian and Babylonian civilizations. Teams of humanities and natural sciences have joined the project and cooperated in making comprehensive surveys. The project aims to understand the formation of ancient Semitic communities by investigating the natural and cultural changes in this region.

We have participated in this project as the geography team and have prepared maps by satellite remote sensing and created a database of ancient sites based on GIS.

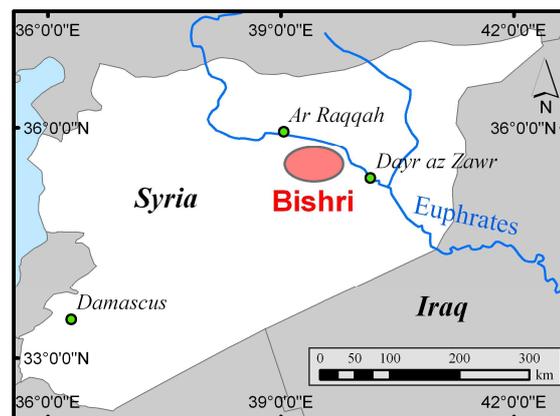


Figure 1. Locations of the Bishri

## 2. MAPPING OF ANCIENT SITES

### 2.1 Objectives of the geography team

Satellite remote sensing and GIS have been widely used to prepare maps of ancient sites. The techniques, which have been found to be effective, have an advantage of enabling targets to be observed from the skies.

Desirably, the research project was to be carried out by conducting related surveys in Iraq. There are many ancient sites in Iraq, which was the center of Mesopotamian civilization. Many of the sites have been targets of destruction and robbery, requiring urgent surveys and protection measures (Fig. 2).



Figure 2. Looting of Um al-Aqarib, Iraq (QuickBird Pan)

However, the unstable political situations after the 2003 invasion of Iraq have impeded such surveys (Matsumoto 2004). An effective protection method involves constructing a database of ancient sites and maintaining and patrolling them based on the database. However, there have been no ample database of ancient sites in the area and no large-scale topographic maps that can be used as base maps. In such a case, satellite remote sensing is effective for conducting surveys (Matsumoto et al., 2007).

We tested preparation of base maps and a database of ancient sites in a region around Tell Ghanem al-Ali in the Middle Euphrates Area, aiming to establish a method and use it for other areas of Iraq and to contribute to the protection of cultural heritage.

### 2.2 Overview of the area surveyed

An area extending 110 km east and west, from Lake Assad to Zenobia Halabiya, in the middle reaches of the Euphrates River was surveyed by satellite remote sensing (Fig. 3). There are "Tell-type" ancient sites in this part of the flood plain of the Euphrates. Tell-type sites are hill-shape remains of villages and cities that were formed by repetitive construction, abandonment, and destruction of mud-brick houses at the same place due to some reasons.

Tell Ghanem al-Ali is one of Tell-type ancient sites located about 40 km southeast from Raqqa, Syria. Joint excavation started in 2007. It extends about 290 m east and west and about 250 m north and south. The relative height is about 10 m (Hasegawa 2008).



Figure 3. Investigation area (Landsat ETM+)

### 2.3 Methods

GIS was used to prepare base maps and a database of ancient sites (Fig. 3).

Ancient sites for which locations have been identified and reported in papers and published reports were converted into vector data. Locations of those that come in raster data were calculated from locational information of ALOS PRISM, which was of the highest accuracy among available our satellite datasets, because the use of GPS receivers at the sites was not permitted. Other geospatial information was calculated by projecting ALOS PRISM data on the UTM coordinates and unifying the datum into WGS84. GIS software programs used were ERDAS IMAGINE, LPS and ESRI ArcInfo.

### 2.4 Use of topographic maps

Available maps were Soviet Military Topographic Maps of 1:100,000 that covered the entire survey area and 1:5,000 maps prepared in Syria, which covered the district around the remains. The Soviet Military Topographic Maps were printed in 1984. They were first prepared in 1952 to 1962 and were revised in 1979 to 1981. The topographic maps of Syria were printed by Euphrates Project Authority, and were prepared by an Italian company in 1961 to 1962.

### 2.5 Maps using satellite data

**2.5.1 Use of middle-resolution satellite data:** Base maps that covered a large area were prepared by mainly using data from ALOS and CORONA.

ALOS is a satellite that was launched by JAXA, Japan, and is loaded with three sensors: PRISM (spatial resolution: 2.5 m), AVNIR-2 (spatial resolution: 10 m) and PALSAR (spatial resolution: 14 m #). PRISM is an optical sensor that can obtain images from Nadir, Forward and Backward. Thus, digital surface models of precision of about 1:25,000 can be constructed by digital photogrammetry. By using ALOS, original and highly precise latest maps can be prepared inexpensively even for areas for which topographic maps are difficult to obtain. A three-dimensional image near Tell Ghanem al-Ali is shown in Fig. 4, which was prepared by digital surface models determined by digital photogrammetry.



Figure. 4 Three-dimensional image near Tell Ghanem al-Ali from east (ALOS AVNIR-2, PRISM DSM)

CORONA was a reconnaissance satellite of the USA. Because photographs were taken also by stereo cameras, the data can be used to reconstruct topography although the precision is lower than that of ALOS PRISM digital surface models. An advantage of using CORONA data is that old satellite images are available. Fig. 5 is an image from CORONA in 1968.



Figure. 5 Image around Tell Ghanem al-Ali (CORONA)

Datasets from CORONA, Landsat, ASTER and ALOS were also collected to cover different periods (Goto et al., 2008). Use of the data enabled recent changes in land cover and channel change to be analyzed (Fig. 6).

### Middle Euphrates

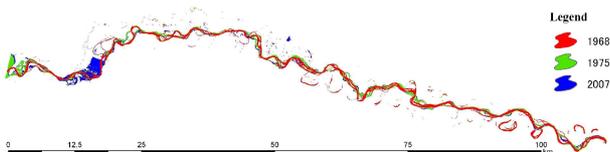


Fig. 6 Channel changes in the Middle Euphrates

**2.5.2 Use of high resolution satellite data:** Base maps of small regions near the ancient site were prepared by mainly using data from QuickBird (spatial resolution: 61 cm). A high-resolution satellite image of Tell Ghanem al-Ali is shown in Fig. 7. Today, the top of the tell-type site is used by village people as Islamic tombs, which are clearly visible. Not only the Tell-type site, but also nearby tombs, which suffered robbery, are visible. Fig. 8 shown looting tombs in Wadi Shabbout near Tell Ghanem al-Ali (Kume 2009).



Figure. 7 View of Tell Ghanem al-Ali (QuickBird Pan)



Figure. 8 View of Wadi Shabbout (QuickBird Pan)

### 2.6 Preparation of ancient site distribution maps

Maps showing estimated distribution of Tell-type ancient sites, which were prepared by mainly using 1:100,000 Soviet Military Topographic Maps and data from SPOT and SRTM, were brought to the field survey in 2007. At the field, the distribution of ancient sites was investigated by checking earthenware pieces collected from the ground surface (Goto et al., 2007).

The information used to estimate the locations of the sites were the legends of the topographic maps, oval bare land areas detected by the satellites, and relative elevation in the data from SRTM. A resultant distribution map of ancient sites is shown in Fig. 9. Since 2008, it has been possible to record smaller Tell-type sites by using ALOS PRISM digital surface models, which have spatial resolution of 10 m.

Figure. 9 Sample image of Ancient sites Distribution map in the Middle Euphrates Area based on GIS

### 3. CONCLUSIONS

This paper described a test preparation of base maps in Syria. Spatial information is considered secret in some areas of West Asia, and it is difficult to collect full datasets. In Syria, topographic and geological maps are available, but aerial photographs and large-scale topographic maps are difficult to obtain. For areas of such restrictions, preparing original maps using satellite data is effective for conducting surveys smoothly. Use of basic techniques of satellite remote sensing is effective for preparing maps for areas for which no maps are available. The prepared base maps and the database of ancient sites will be used as basic information for investigating the locational conditions of ancient sites. The authors wish that this method will be an effective tool for protecting cultural heritage, which are common properties of all humanity and are faced with the threat of destruction and robbery, in areas where it is difficult to visit, such as Iraq.

### Selected Bibliography

- Goto, T and Hasegawa, H., 2007. Tell distribution survey using Soviet Military Topographic Maps: A Case study around the Middle Euphrates Area in Syria. *Newsletter of Integrated Research in the Bishri Mountains on the Middle Euphrates*, 8, pp. 16-19. (Japanese)
- Goto, T., Hasegawa, H and Matsumoto, K., 2008. Preparing multitemporal base map using data from CORONA, LANDSAT and ALOS: Changes in land cover and river course near Tell Ghanem al-Ali in 39 years as an example. *Newsletter of Integrated Research in the Bishri Mountains on the Middle Euphrates*, 12, pp. 7-10. (Japanese)
- Hasegawa, A., 2008. Survey of Tell Ghanem al-Ali. *Newsletter of Integrated Research in the Bishri Mountains on the Middle Euphrates*, 10, pp5-9. (Japanese)
- Matsumoto, K., 2004. The State of cultural heritage at the era of post-Iraq war: The findings from the UNESCO Experts Mission. *al-Rafidan*, 25, pp43-56. (Japanese)
- Matsumoto, K., Hasegawa, H., Ushiki, H and Goto, T., 2007. The Making of the Base Maps of the Ancient Sites in the Mesopotamian Region based on ALOS Data. *Proceeding of The First Joint PI Symposium of ALOS Data Nodes for ALOS Science Program in Kyoto* (CD-ROM ISBN: 978-4-906653-04-1).
- Kume, S., 2009. Survey of the Early Bronze Age tombs near the Tell Ghanem al-Ali. *Newsletter of Integrated Research in the Bishri Mountains on the Middle Euphrates*, 14, pp. 11-19. (Japanese)

### Acknowledgments

This research has been supported by grant-in-aid projects for scientific research on priority area (2005-2009) of the Ministry of Education, Culture, Sports, Science and Technology of the Japanese government, entitled "Formation of Tribal Communities in the Bishri Mountains, Middle Euphrates (Principal Investigator: Katsuhiko Onuma) and "Developing Database of Archaeological Sites in West Asia: An Investigation through the Analysis of Satellite Images (Principal Investigator; Ken Matsumoto), the latter of which is for the Planned Research Team.

The data from ALOS and RPC information used in this study were high-level products prepared at JAXA EORC under the agreement of JAXA Research Announcement entitled "The making of the base map of the ancient sites of the Mesopotamian region and its utilization" (JAXA-PI418, Ken Matsumoto).