Spatial Analyses of Harappan Urban Settlements

Hirofumi Teramura* **and Takao Uno***

Abstract

The Harappan Civilization occupies a unique place among the early civilizations of the world with its well planned urban settlements, advanced handicraft and technology, religious and trade activities. Using a Geographical Information Systems (GIS), this study presents spatial analyses that locate urban settlements on a digital elevation model (DEM) according to the three phases early, mature and late. Understanding the relationship between the spatial distribution of Harappan sites and the change in some factors, such as topographical features, river passages or sea level changes, will lead to an understanding of the dynamism of this civilization. It will also afford a glimpse of the factors behind the formation, development, and decline of the Harappan Civilization.

Introduction

The Harappan Civilization occupies a unique place among the early civilizations of the world. It is particularly worth noting that Harappan urban settlements were well planned, consisting of citadels and downtowns with grid-patterned streets, advanced handicraft techniques were used, and that many remains of religious and trade activities have been found. It has also been noted that no royal tombs or administrative establishments have been found, and that there are few artifacts indicative of powerful rulers.

Using a Geographical Information Systems (GIS), this study presents spatial analyses that locate urban settlements on a digital elevation model (DEM) by period. Understanding the relationship between the spatial distribution of Harappan sites and the change in some factors, such as topographical features, river passages or sea level changes, will lead to an understanding of the dynamism of this civilization. It will also afford a glimpse of the factors behind the formation, development, and decline of the Harappan Civilization.

The Harappan Civilization in this article includes the early, mature, and late Harappan cultures.

**International Research Centre for Japanese Studies, Kyoto, Japan*

1. Data and Methods of Analyses

Site information including names, locations (latitude and longitude), periods, and areas based on the "Indus Age" (Possehl, 1999) were stored in a database of archaeological sites. The number of sites from the "Indus Age" was 2502, of which 2020 sites were chosen for our analyses because of their clearly defined latitudes, longitudes, and time periods. The location of the Kanmer Site (from the mature and late Harappan periods) was recorded by Uno using GPS. Periods are divided into seven stages based on their classification within the "Indus Age," and sites that cut across stages are counted separately in each stage.

The calendar eras for each stage are as follows. (Possehl, 1999)

Stage 1 : 7000-5000 BC
5000-4300 BC (Beginnings of village farming communities and pastoral camps)

Stage 2 : 4300-3800 BC
3800-3200 BC (Developed village farming communities and pastoral societies)

Stage 3 : 3200-2600 BC (Early Harappan)

Stage 4 : 2600-2500 BC (The Transition from Early to Mature Harappan)

Stage 5 : 2500-1900 BC (Mature Harappan)

Stage 6 : 1900-1000 BC (Post-urban Harappan)

Stage 7 : 1000-600 BC (Early Iron Age)

For the targeted areas, we used an SRTM 3 arc second mesh (approx. 90 m) and an SRTM 30 arc second mesh (approx. 1 km) from NASA, and we used SRTMER, an application created by Mr. Izumi Niiro to convert the DEM into a format that can be read on IDRISI, a GIS display and analysis program. Then we converted the database for archaeological sites and the DEM into GIS format.

For each site, we analyzed *runoff, density distribution, viewshed and sea level change* using IDRISI.

2. Analyses of the Entire Area of the Harappan Civilization

Fig. 1 shows sites plotted from all stages of the Harappan civilization on the DEM for the targeted area. Sites extend from the Baluchistan hills in the west to the upper Ganges River basin in the east to the Saurashtra peninsula in the south, with the highest site density centering on the Indus plain.

We conducted a density analysis to examine the changes in site distribution during various stages (Fig. 2). The dark blue in the figures indicates the high density of sites.

Sites were concentrated around the Baluchistan hills in stage 1 while in stage 2, sites were distributed throughout the middle Indus River basin in addition to the Baluchistan hills. In stage 3, the distribution expanded to the east, and there was also a concentration of sites in the upper Ganges River basin. Characteristic of stage 4 is the appearance of sites in Gujarat,

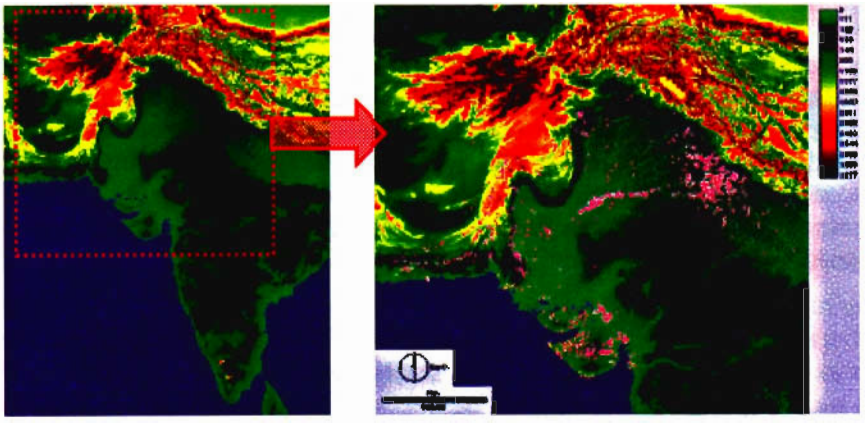

Fig. 1: Targeted areas on the DEM and site distribution (all stages)

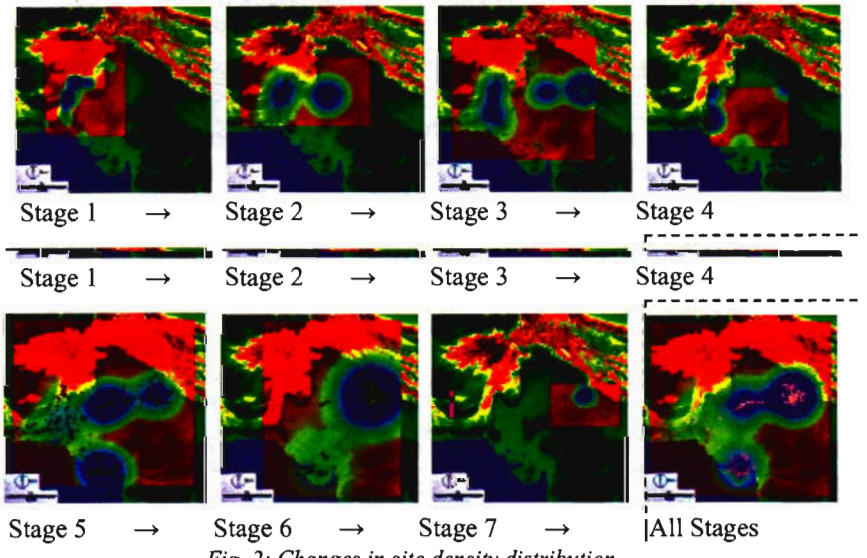

Fig. 2: Changes in site density distribution

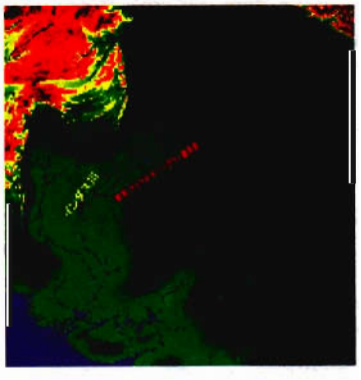

Fig. 3: Restored river passages estimation

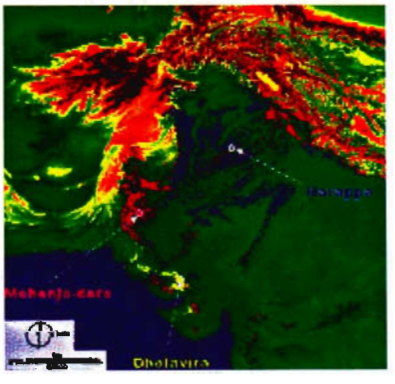

Fig. 4: Range of visibility from three sites

although they are few in number. In stage 5, the number of sites increase dramatically, and many sites appear on the Saurashtra peninsula. During this stage three high-density areas can be identified; within Gujarat, in the middle Indus River basin and in the upper Ganges River basin, and there were also sites in the Baluchistan hills. In stage 6, the density distribution was polarized between the upper Ganges River basin and Gujarat, although the former had more sites than the latter. In stage 7, sites appear only in the upper Ganges River basin, and there are no sites in the middle Indus River basin, the Saurashtra peninsula, or the Baluchistan hills.

Using runoff analysis modules, we restored river passages on Fig. 3. On the map, one river has been restored on the east of the current middle Indus River basin, but there is no river there now, and it can be assumed that this is the dried-up Ghaggar-Hakra riverbed. However, we used a 1km mesh DEM, and further analysis using a DEM with a smaller mesh will be necessary.

We conducted viewshed analysis of some famous Indus Civilization sites: Harappa, Mohenjo-daro, and Dholavira (Fig. 4). The visibility ranges on the map show that the Harappa and Mohenjo-daro sites are situated where they can overlook the upper and lower river basin of the Indus plain. There is nothing to obstruct the view between Mohenjo-daro and the Indian province of Gujarat. Each of these sites is not visible from the other, but by conducting viewshed analysis it will be possible to glimpse why these huge sites, representative of the Harappan Civilization, were located where they were in the Indus plain.

representative of the Harappan Civilization, were located where they were in the Indus plain.

3. Sites in Northwest India

Fig 5 shows sites of the northern Saurashtra peninsula and around the Rann of Kutch on the DEM as dots (the Dholavira and Kanmer sites are indicated as stars). The Rann of Kutch, as the name indicates, is where water accumulates in the rainy season and where the water dries and land appears in the dry season. This area is almost at sea level, and some places are indicated in gray on the DEM even though they are now dry land. This is due to the accuracy limitations of SRTM, but we used the elevations of the DEM data as they were, and did not intervene to correct them. The site distribution clearly shows that sites were built on higher elevations, avoiding the areas inundated with water in the rainy season.

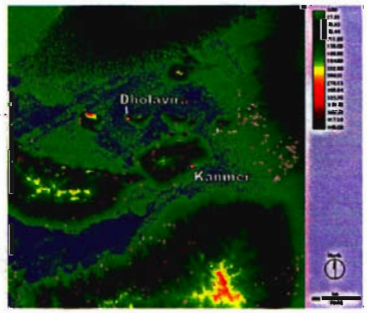

Fig. 5: Area surrounding the Rann of Kutch on DEM

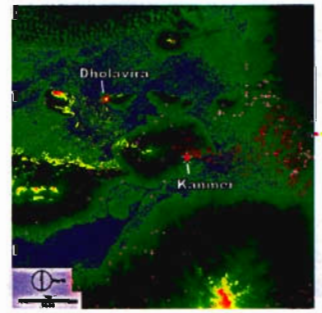

Fig. 6: Range of visibility from Dholavira and Kanmer sites

Fig. 6 shows the range of visibility from the Dholavira and Kanmer sites. The visibility from Dholavira extends from the south to the southwest, while the view from Kanmer covers the closed-off section of the bay from the east to the southeast, and there is no reciprocal visibility between the two sites. However, it can be said that the two sites were located at perfect places, overlooking the outlet of the bay (to the west) and the closed-off section of the bay (to the east), to get a clear picture of marine traffic. This suggests that the navigation route was significant. Thus it is proposed that the closure of the seaway due to the lowering of sea level was contributory to the decline of the sites in Gujarat province and consequently of the Harappan Civilization.

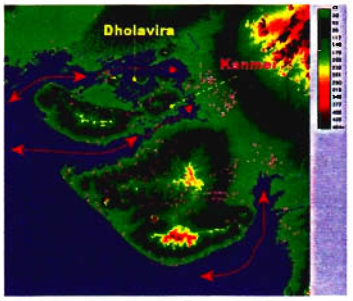

Fig. 7: Sea level is raised 1 m

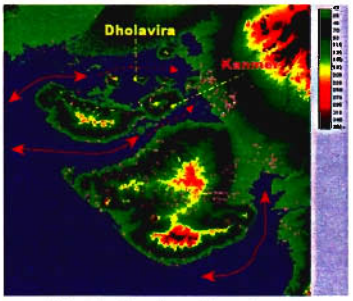

Fig. 8: Sea level is raised 3 m

Figs. 7 and 8 use GIS to show a simulated transformation of the seaway due to sea level changes. In Fig. 7, it can be seen that sea level has been raised 1m, and the sea continues through the closed-off section of the bay. In Fig. 8, sea level has been raised 3 m, and it is

Figs. 7 and 8 use GIS to show a simulated transformation of the seaway due to sea level changes. In Fig. 7, it can be seen that sea level has been raised 1m, and the sea continues through the closed-off section of the bay. In Fig. 8, sea level has been raised 3 m, and it is conceivable that it was possible to travel by ship to the area where sites were concentrated at the root of the Saurashtra peninsula. We speculate that direct navigation by ship would have been possible with a 1.5 m-rise in sea level, that the channel was closed with just a 1m-rise in sea level, and that isolation increased as sea level fell further. We assume that this closure of the seaway was a factor in the decline of the Harappan Civilization.

We used a coarse 1 km DEM mesh for sea level change and our results are based on a simulation using this coarse elevation data. More in-depth analysis will be needed using a finer scale DEM, while considering the current sea level elevation around Gujarat and also adding data obtained in field surveys. We will continue to revise our work while incorporating information from future surveys.

Conclusion

We conducted a study of the distribution of cities and settlements of the Harappan Civilization using GIS. The following findings emerged for each stage.

Stage 1:

Sites were concentrated in the Baluchistan hills to the west of the Indus plain. It is probable that the Harappan Civilization originated with the Neolithic culture of the Plateau of Iran shifting eastward (Agrawal and Kharakwal, 2003), and it can be assumed that this stage immediately preceded the adaptation of Neolithic culture to the environment of the Indus plain.

Stage 2:

This stage is characterized as the period of immigration into the Indus plain. It is assumed that the living environment of the Indus plain was improved by significant increases in precipitation and warming temperatures (Singh et al., 1973; Bryson, 1988; Agrawal and Sood, 1982). In stage 2 (Mid Holocene), it is probable that both summer and winter rainfall increased, and agricultural production became more stable. In particular, there is a concentration of sites near the site of Harappa and it is possible that the Ravi River passage and its water flow became stable. Elucidating archaeological factors, including whether or not bunds which existed in the mature Harappan culture also appeared at this stage, is a subject for future investigation.

Stage 3:

While the number of sites in the Indus plain increased, settlements near the seashore such as in northwest India and sites in the upper Ganges River basin also appeared. Many characteristic elements of the mature Harappan Civilization emerged, for example, silver, lapis lazuli, and steatite ornaments were distributed widely, and citadel walls were built. It is conceivable that the backbone for the mature Harappan Civilization formed during this period in terms of site spatial distribution and also cultural and social elements.

Stage 4:

The number of sites decreased rapidly (dramatically). This phenomenon can be interpreted as meaning that there were great social changes just before the formation of the mature Harappan Civilization or that the span of stage 4 was very short. Because earthenware from the end of the early Harappan and from the beginning of the mature Harappan has been excavated side by side (Agrawal and Kharakwal, 2003), we prefer to assume that the span of stage 4 was very short.

Stage 5:

This was the mature phase of the Harappan Civilization. The Harappan sites are centered on the upper Indus River basin, and the Indian province of Gujarat, which form the two largest areas of concentration of the Harappan civilization, followed by the upper Ganges River basin. There are many sites in the lower Indus River basin, where the site of Mohenjo-daro is located, and also on the hills to the west of this area, but here the concentration is comparatively lower. As the site concentration is higher in Gujarat and the upper Indus River basin, it suggests that trade with West Asia via Oman was carried out by this region which supported the prosperity of the mature Harappan Civilization.

Stage 6:

This stage was the beginning of the decline of the Harappan Civilization. There are different theories about the causes of the decline. The spatial distribution of sites shows a decreasing number of sites around Mohenjo-daro and on the hills to the west and a simultaneous increase in sites in the upper Ganges River basin. This suggests that there was a shift from concentrated residence in cities to dispersed residence, or that the population moved from the west to the east.

In addition, the number of sites in the upper Indus River basin including the site of Harappa decreased while many sites in Gujarat continued. It is thought that these spatial changes occurred due to the deteriorating environment in the Indus plain. It is a possibility that trade activity increased the tolerance for these environmental changes.

Stage 7:

This stage is perceived as the period when the Harappan Civilization fell into relative obscurity, moving to the upper Ganges River basin. Possible explanations of the decline of the Indus Civilization are provided by the environmental deterioration theory. From site spatial analysis, we can assume that the decay of the sites in and around Gujarat was a significant factor. This suggests that in addition to the colder and drier weather, the diminished port capability associated with a falling sea level may have been a factor in the decline of the Harappan Civilization.

We examined the rise and fall of the urban settlements of Harappan Civilization by spatial analyses using GIS. We examined a wide range of events, whose relationships make it reasonable to presume that trade activities played an important role in this early civilization's development and maintenance, and that its transitions were closely related to environmental changes.

In this paper, spatial analyses using GIS were conducted with currently available spatiotemporal information on Harappan Civilization sites. We are planning to carry out further research on the Harappan Civilization from a multilateral perspective by obtaining more information about the Harappan Civilization and integrating it with GIS. By doing this, we will be able to clarify the significance of the Harappan Civilization in the history of mankind.

Acknowledgements

This study was conducted as part of the Research Institute for Humanity and Nature's Indus Project. We would like to thank the project leader, professor Toshiki Osada for his indispensable assistance. We also received assistance from Dr. Kharakwal about the GPS survey of the Kanmer site in the Indian province of Gujarat. Mr. Kengo Miyahara of the Kyoto City Archaeological Research Institute also advised and assisted us in obtaining and correcting survey data. Lecturer Masakazu Nakatani at the International Research Center for Japanese Studies helped us with the input of the spatial data. We would like to express our appreciation to everyone.

References

Agrawal, D.P. and J. S. Kharakwal. 2003. B*ronze and Iron Ages in South Asia,* Aryan Books International, New Delhi.

Possehl, G. L. 1999. *Indus Age The Beginnings*, University of Pennsylvania Press, Philadelphia.

Singh, G., S. K. Chopra and A. B. Singh. 1973. Pollen-rain from vegetation of North-West India, *New Phytology* 72, pp:191-206.

Bryson, R. A. 1988. What the climatic past tells us about the environmental future; *Earth* 88: 230-247.

Agrawal, D. P. and R. K. Sood. 1993. Ecological factors and the Harappan civilization in G.L. Possehl *ed. Harappan Civilization, Oxford and IBH Pub. Company, New Delhi, pp223-235.*