# THE HUMAN/ENVIRONMENT INTERFACE OF MAYA SETTLEMENTS

# GIS in Archaeology

Throughout history the physical and cultural environment has influenced location and distribution of settlements. One important question in archaeological research is what are the causal relationships between environmental factors on the one side and location and distribution of settlements on the other? The authors demonstrate GIS to be a powerful analytical tool in finding answers to this question as it relates to Maya settlement patterns in Central America.

Clues to the relationships between environmental factors and location and distribution of settlements are preserved in many existing maps. Combining these maps with remote sensing data and non-spatial information from a variety of sources in a geo-DBMS enables the creation of virtual models of archaeological sites and querying relationships or adjacencies between disparate forms of physical and social data at household, cluster, site and regional level. Such GIS has the potential to incorporate a limitless amount of information for analyses, to predict the presence of undocumented archaeological sites and to discover heretofore-unidentifiable relationships.

**Maya Settlements**
The ancient Maya inhabited all of Belize, Guatemala, El Salvador and parts of Honduras and Mexico. Early Maya settlements first appeared in various parts of the region between 1700 BC and 200 AD. The Maya practised slash-and-burn horticulture, enabling them to establish permanent villages throughout Mesoamerica. Beyond its karstic landscape, the salient physical characteristic of a major portion of the YucatÃ¡n Peninsula is a seasonal scarcity of surface water. Slash-and-burn agriculture and the physical environment of northern YucatÃ¡n are centrifugal factors serving to maintain dispersed populations.

Existing Data
Existing collected data covering the site of ChichÃ©n ItzÃ¡ and its environment includes:

- maps published from 1843 to 1999
- scale 1:4,000 and 1:15,000 standard and 1:75,000 scale ortho-rectified air photos provided by The National Mexican Topographic Survey (INEGI)
- scale 1:50,000, 1:250,000 and 1:1,000,000 topographic and thematic maps provided by INEGI; thematic maps plot incidence of a variety of physical characteristics including climate, rainfall, soil types and vegetation coverage, surface and subsurface hydrology and geology
- Landsat Thematic Mapper, Shuttle SIR-C Radar, and SRTM coverage provided by NASA and the USGS
- non-spatial data including architectural styles found at the site and artefact-find frequency collected from various publications and Mexicoâ€™s National Institute of Anthropology and History (INAH) site reports.

Identifiable elements, including building corners, stairs and doorways, or natural features such as cenotes, water-filled sinkholes and outcrops were selected from existing maps or vector datasets. In the field Trimble GeoExplorer III was used to take multiple lat/lon measurements for each pre-selected reference point. Centroids for each group of 150 to 200 positional readings were calculated using Trimble Pathfinder Office software.

Creating Geo-DBMS
GeoMedia Professional 5.1 package from Intergraph was used to build a geospatial data management system (geo-DBMS) containing data for over two thousand archaeological sites. Single points representing the spatial means for each cluster of readings at a unique location were exported into Geomedia as shape files. After plotting, the shape files were exported as point features to a Microsoft Access database. Then positional features (points) were matched with map elements in TIFF files or vector elements in CAD files. Next, map elements were digitised as vector features (points, lines or areas) in GeoMedia. Each feature represents a unique entity, plotted in its geographic location relative to other map elements. Non-spatial attributes such as architectural style, functional elements, burials and associated artefacts were linked to map features in the geo-DBMS and each feature was classified. Thus certain features, whether points, lines or areas, were coded to represent various categories of architecture or entities. This method enables modelling ancient sites in a scaled, virtual space while preserving measurable spatial relationships, including significant associations and context. At the design stage seven classes of architectural elements, a unique symbol for metates (ancient grinding stones), and nine types of water-resource feature were created. Additional categories were created as needed, on a site-by-site basis.

Field Testing
To test the accuracy of the data stored in a single geo-referenced design file, a field survey was undertaken. First the lat/lon coordinates of map elements stored in the geo-DBMS were transferred to a Garmin GPS III unit; attempts were then made to find these features back in

the field. At ChichÃ©n ItzÃ¡ all features were found; at DzibilchaltÃºn fifteen out of sixteen water features were located. The only feature not found was a well that had probably been destroyed by tree roots or overgrown by vegetation in the forty years since completion of the paper map used as a base map. During fieldwork several sites were discovered. The Akalchen, a Mayan word meaning â€˜dark wellâ€™ was discovered approximately 3.5km North Northeast of ChichÃ©n ItzÃ¡. Coordinates of the discovered sites were collected using GPS, and structures were mapped using a total station. The completed maps were incorporated into the system.

## Linking Other Data

Existing maps were then registered, digitised and verified in the field; attributes were assigned to the map features using relational tables. All classes of micro-scale physical or cultural, spatial or non-spatial data were linked to features or settlement units at household, cluster, site and regional scale. Site-specific data relevant for comparison at community or site level included topography, soil types, land coverage, localised climatic data, available technology and accessible natural resources. As fieldwork progressed some data, including ceramic and artefact-find frequencies, architectural styles or functional classifications and newly mapped sections of the site were stored in the geo-DBMS.

## Results

Plotting the distribution of known archaeological sites in the northern part of the Maya Lowlands shows that substantially large areas had no apparent settlements. The distribution of populated locations from the 2000 Census of Mexico layered over prehistoric sites suggests that in some instances past causal factors might also influence modern-day location. Further, the modern pattern argues for more extensive exploration of the region. Indeed, events that occurred millions of years ago continue to influence the human landscape. Shuttle Radar Topography Mission imagery reveals crescent-shaped distribution of sinkholes penetrating the aquifer in the north-western part of the peninsula known as the Ring of Cenotes. Documented natural or culturally modified lakes are known as aguadas. Ancient settlements appear clustered in several areas. One major concentration of settlements occurs inside the ring. Chultunes were most frequently found outside the Ring of Cenotes.

To study spatial relationships between water features and architectural elements, buffer zones 500m wide were placed around natural water features in the geo-data of ChichÃ©n ItzÃ¡. In all instances where no additional natural water sources existed outside the buffer area evidence of the constructed water-storage reservoirs known as chultunes appears in architectural groups. The 500m buffer zones touch but rarely overlap by a measurable distance. This non-random, patterned distribution of chultunes suggests that water features served areas covering approximately 0.8km2. Moreover, 500m seems to be the maximal distance over which inhabitants of ChichÃ©n ItzÃ¡ were willing to transport water in ceramic water jars. Buffer zones placed around chultunes at the site of Becan, 260 kilometres to the south, showed similar patterned results.

Ancient wells occur only at sites where the fresh-water aquifer is no more than 20 to 30 metres below ground surface. Wells and frequency of occurrence of these was significantly higher within the ring of cenotes; at some sites frequency approached twenty wells per km2. Aquifer depth in the area appears to be influenced by relic crater.

The archaeologists used the site grid and employed spatial queries to accomplish quadrant analysis for the site of Calakmul, approximately 30km north of the Guatemalan border. Analysis
indicated that the earliest construction at the site took place near natural water features and the location of architectural features at the site is non-random.

## Concluding Remarks

The use of GIS enables integration of maps created over a century ago with data relevant to the study of ancient Maya settlements, giving long-silent mapmakers a new voice and enabling them to contribute to a better understanding of the human/environment interface.

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## Further Reading

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