Sustainable heritage in Mexico: archaeological solutions for infrastructure planning and building

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Abstract

Mexico is a country that requires the construction and expansion of infrastructure to increase the competitiveness of its economy. Building this highly competitive logistic platform has had an impact on Mexico's cultural and social heritage. In the State of Morelos, the municipalities of Cuernavaca and Jiutepec considered that sustainable development could be integrated with heritage preservation at the time of land use plans' designing and adoption. Hereby described, a geographic information system-based predictive model, differentiating areas by their potential for different types of resources, is suggested as a solution to protect Mexico's heritage within a uniform permitting and compliance process.

Introduction

In Mexico, archaeological resources remain in a defenseless state against the intense and rapid building of infrastructure to promote economic growth. Measuring the benefits and adversities of development projects is centered on the environment, without accommodating the clear mandated responsibility to protect Mexico's heritage in the design of impact assessments. The National Institute of Anthropology and History (INAH) lacks sufficient staff and adequate funding from the federal government to fulfill its responsibility of protecting Mexico's heritage in this intensive building context (Paredes Gudiño, 2006). In the absence of a heritage management industry in Mexico, the federal government is bounded by law to absorb the full costs of heritage management (Altschul and Ferguson, 2010), leaving INAH in a vulnerable stage to prevent the destruction of people's valued and significant spaces.

The people of Mexico have expressed their discontent to this situation, demanding their voices to be heard and their right to participate in the design of infrastructure development projects, as clearly stated during the construction of a COSTCO store on the grounds of the hotel *El Casino de la Selva* in 2002 (López Varela and Dore, 2009). In 2007, the municipal authorities of Jiutepec and Cuernavaca approached the Geographical Information Systems Laboratory at the University of Morelos and to help them find ways of integrating sustainable development with heritage protection in their land-use plans. The innovative request and inexperience of environmental planners in considering heritage management processes in policy-making and institutional planning activities required a collaborative effort with Statistical Research Inc. (SRI), a cultural resources firm, having the experience to conduct fast-track projects in large spatial areas. The methodological proposal presented to the municipalities to protect heritage resources was already in use by environmental planners. In areas of concern to planning, land-use plans already include spatial decision support systems (SDSS), use of information technologies for data collection and consulting, deliberative processes, and predictive modeling in an integrated spatial planning framework. Basically, an archaeological approach had to be integrated and to consider the relationship between space-time and nature-society (Conolly and Lake, 2010). To minimise risks, environmental assessment plans include collaborative planning as a main strategy to provide citizens with the opportunity to express their opinion or expertise through their knowledge of a problem or by devising a solution. However, collaborative planning cannot entirely contribute to sustainable growth. The process of deliberation stands for limited citizen representation, as the stakeholders are selected to participate based on their leadership, their contribution to society, or as representatives of a government program or agenda. The absence of other voices provides an underrepresented model, leading to the familiar unrest. The solution is to design a more people-focused approach, with the acquisition of value-based data by sampling the targeted population, which in return contributes to a better sustainable conservation of natural and heritage resources.

The following pages discuss the relevance of introducing an archaeological perspective in land-use planning and brings to the attention of the archaeologist that, the exclusive use of a geographic information system (GIS), without further consideration of the current management processes and definition of heritage, restricts its capacity to protect Mexico's heritage. Without a process that can be expanded and used to minimise adverse effects on heritage resources or without contemplating the values and knowledge of the people of these two municipalities, as demonstrated here, the quality of the GIS dataset and structure is compromised. Thus, the commitment to protect Mexico's heritage moves the discussion beyond GIS as a software tool describing a GIS-based predictive model, differentiating areas by their potential for different types of resources. Instead, the discussion is concerned about promoting a geographic information science concerned with the space-time relationships between natural and social phenomena.

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How to place heritage in land-use plans

Undoubtedly, the restricted financial setting for archaeological investigations in Mexico is a relevant factor to protect her heritage. Fortunately, new methodologies and techniques assessing the characteristics of the landscape and to inform planning decisions, such as predictive modeling, are powerful tools to protect Mexico's heritage at a relatively low cost. Already in Mexico, predictive modeling is essential to policy makers in choosing the best location to build a road or to develop economic activities.

In environmental management, a GIS is regularly used as a modeling tool to generate new parameters representing the environmental impacts of actions or the number of people exposed to risk from spatially referenced data (Peckham, 1997). Measuring the environmental impact on people is based on the recovery of demographic data, without incorporating the values or feelings people place on the landscape (Low, 2008). In archaeology, the use of a GIS considers the relationship between space-time and nature-society (Conolly and Lake, 2010). Since a GIS characterises by the capacity to integrate spatially referenced information coming from different sources, this archaeological equation can easily be integrated as another thematic map layer of sustainable development projects.

The power of a GIS relies on the quality of its database. Recently, INAH has been using a GIS to record and manage archaeological data (Sánchez Nava, 2007). However, historic and modern heritage resources are absent from the database. Modern heritage resources are managed by the Instituto Nacional de Bellas Artes (INBA), running very different permit process to access its database. Data partition relates to the prevailing definition of heritage resources and institutional dynamics in Mexico, affecting how data is collected and managed. The constitution of the databases reveals the absence of national management standards and strategies for the management of heritage resources. The time required to obtain permits to access the data at INAH and INBA is incompatible with the common 30-day framework to produce the land use models required by the municipalities.

The University of Morelos has a cooperation agreement with INAH. Still, the database was impossible to obtain and to be included in the land use plans. Even if we had had access to the databases, the information would have proved to be insufficient. The INAH database was incomplete as it lacked information on historic resources and the INBA database has no data of any resource type beyond the 19th century, except for those with an aesthetic value. Having a GIS without an efficient conceptualised uniform permitting and compliance process giving fast access to data layers is not the best way to prevent the destruction of Mexico's heritage. For both municipalities, the identification of heritage resources was based mostly on the literature. Data collection to define heritage resources for both municipalities included those sites listed at INAH in Cuernavaca (Centro Regional del INAH-Morelos) and Mexico City (Registro Público de Monumentos y Zonas Arqueológicas). However, the INAH archives provide no records of archaeological sites in the municipality of Jiutepec or evidence of a systematic survey to determine their presence. Given that we lacked the appropriate permitting from INAH to carry a surface survey, the historian taking care of the heritage documents and archives of Jiutepec guided us through the streets and fields of the municipality, demonstrating the irrevocable presence of archaeological sites that INAH still has to systematically record. The information was not taken into consideration to create the predictive models. The sites were located on a map for comparative purposes and to help us validate the predictive model later on. Additionally for the municipality of Cuernavaca, we included the information provided by INAH, but also considered the information on historic and modern resources provided by the multiple stakeholders participating in the public workshops. Knowing that the stakeholders hold particular agendas in this type of projects, it was decided to take into account the views of the ordinary citizen of the municipality of Cuernavaca (Figure 1) for the creation of the land-use plan. The strategy required the collection of data by sampling the population living in the municipality of Cuernavaca. Given the population size of the municipality, approximately 349, 102 inhabitants in 2005, we established a quota sample of a thousand individuals to be interviewed non-randomly, by choosing a maximum of three houses or individuals per street. The questionnaire was designed so that the citizens of the municipality could identity heritage and environmental resources. To interview its citizens, the municipality of Cuernavaca was subdivided in 10 defined ecological zones, each divided into five environmental management units (EMU). Twenty people were interviewed for each EMU. Even if this is not the most representative of samples, it was extremely useful to demonstrate the limited citizen representation at public workshops with a profiled stakeholder. Obviously, it is impossible for this case to assess the sampling error, even more, when the guards of the wealthiest gated community of Cuernavaca did not allow our collaborators to interview the people living in this area. Instead, our collaborators move to the city center of Cuernavaca to do the interviews.

Results from this experimental stage reveal that the citizen of the municipality of Cuernavaca recognises valuable elements present in the social and natural landscapes that would never be considered as heritage resources by UNESCO, INAH, the academia or the stakeholders. The future city of Cuernavaca, according to 62% of the sampled population, must include an orderly presence of heritage resources. The future city should preserve the traditional neighborhoods of Acapatzingo, Gualupita, and Tlaltenango. The management of urban transit

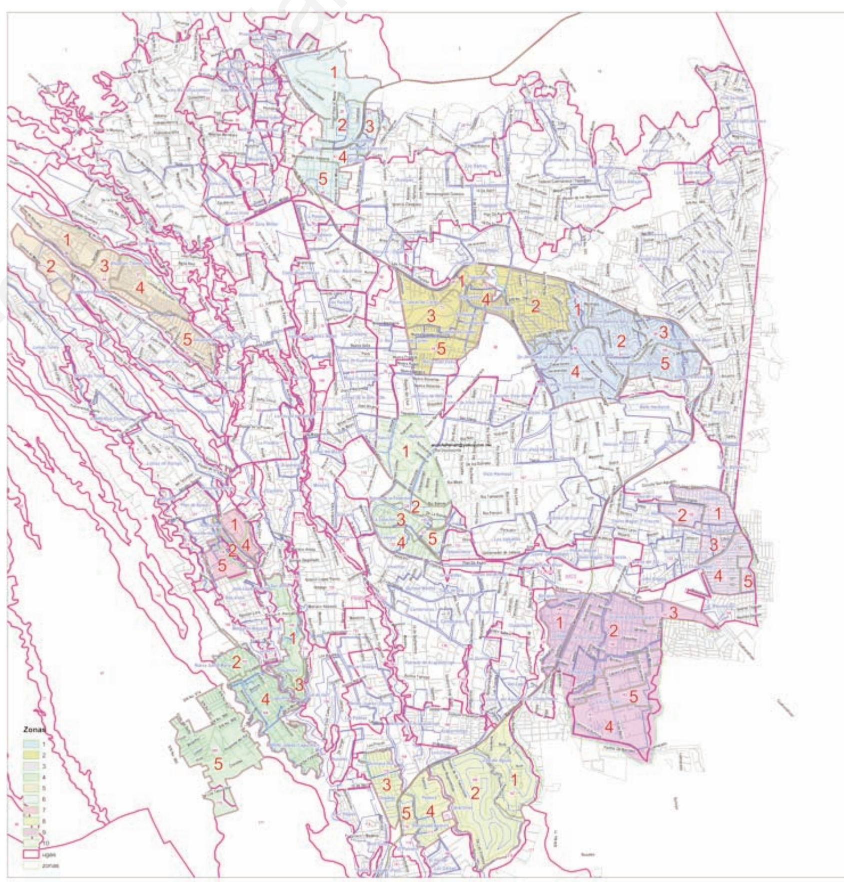

Figure 1. Spatial distribution of population sampling along ten ecological zones, each defined into five environmental mapping units. Courtesy of Valentino Sorani, University of Morlos.

has to consider the presence of weekly markets, the closing of streets to celebrate the festivity of a patron saint in a neighborhood. The design of the ideal future city by its citizens encourages a debate about the definition of heritage resources. Citizens of Cuernavaca demand their parks, theaters, hotels, restaurants, cinemas, soccer courts, or a view of the mountains from the top of an avenue, to qualify as dignified resources (Dore and López Varela, 2010). Citizens demonstrating on the streets to defend their daily living spaces should not surprise planners or authorities, as these spaces express social values, the identity of the community or their beliefs. The urban spaces and architecture of tomorrow should be designed with a sense of place attachment. The people of Mexico, as expressed by the citizens of Cuernavaca, are demanding that other type of resources, besides those specified in its 1972 Law (*Ley Federal sobre Monumentos y Zonas Arqueológicos, Artísticos e Históricos*), be protected and preserved. Thus, a reevaluation of heritage is recommended because one has to understand that tomorrow's archaeological sites are being created today, that history is happening now, and that the material expressions of modern life are the cultural heritage of the nation's future. Concurrently, these are data that people are demanding to be considered as part of land use plans (López Varela and Dore, 2008). With the information recovered for both municipalities through these strategies, we defined three types of resources (i) archaeological, (ii) historic, and (iii) social. Archaeological resources were defined according to INAH's law as the natural and built environment of those present before the arrival of the Spaniards and their created objects, as well as, their encountered human remains. The production of material culture between the 16th to the 19th centuries, mostly limited to written documents and a built environment of religious, military, and state architecture, comprehends the definition of historic resources. However, we added public works and significant buildings such as mills or factories from these centuries, as demanded by the average citizen. Social resources comprehend the protected artistic works exhibiting aesthetic values and added modern locations and the feelings of association, character, and identity that the material and immaterial world creates in the inhabitants of these two municipalities.

Approaching predictive modeling for heritage preservation

In a setting in which data is absent, one can only predict the presence of archaeological resources to mitigate infrastructure growth with a predictive model. In this case, predictive modeling is a powerful tool to protect heritage resources, as it tries to determine the probability of archaeological settlements occurring in a non-sampled area, on the basis of quantitative assessment of the locational characteristics of settlements in a surveyed area. However, the lack of a systematic approach to recover the data restricts the possibility of creating a predictive model based on the correlation between the location of archaeological sites and environmental variables. Thus, the project could only establish some base-line conditions and a process that could be expanded and used to minimise adverse effects on archaeological resources.

Developing land-use plans for both municipalities followed a similar strategy of producing a GIS-based predictive model that differentiated areas by their potential for different types of cultural resources, based on an excellent settlement survey in the Yautepec Valley, east of Jiutepec (Hare, 2001). The known correlations between the archaeological sites and the characteristics of the landscape from this neighboring region were used to create a model that differentiated areas by their potential for different types of cultural resources. Similar to any other predictive models, Hare tied site locations to environmental variables, such as slope, distance to water, soil type, drainage and relief. In a sense, the correlative work had already been done.

Although we lacked the quantitative statistical component that we would have had in a true correlative modeling effort, relationships and patterns could clearly be defined. The application of these relationships used the following environmental layers to create the model for Cuernavaca (Altschul *et al*., 2006): i) soils (layer converted to a 10 m grid of pixels, classified grid based on seven categories of soil fertility, reclassifed values from 6 to 255, 5 to 204, 4 to 153, 3 to 102, 2 to 76, 1 to 51, and 0 to 0); ii) drainage [continuous grid based on the proximity of hypothetical drainage systems, hypothetical drainage systems calculated by the digital elevation model (DEM) reclassified to 10 m pixels, calculated drainage based on a hierarchy of 3, and values within a 0 to 255 range (highest value indicates proximity to water)]; and iii) slope [continuous grid based on slope values, hypothetical slopes calculated by the digital elevation model (DEM) reclassified to 10 m pixels, values within a 0 to 255 range (highest value indicates less slope)]. All variables were scaled to 8 data bits with a range scale of 0 (low) to 255 (high).

These relationships were imposed on the natural resource data of the project area in a rapid exercise of thresholding and map algebra. The resulting model (Figure 2) consists of three layers with the following values: soils+drainage+slope. The model was calculated by the addition of these three layers and reclassified in 10 intervals of equal classes and then recoded to a scale between 1 (low) and 10 (high). The known archaeological sites were included in the model, but note that much of the project areas are under urban/suburban infrastructure obscuring most surface indicators. The potential to damage archaeological sites while carrying infrastructure development is very high for the municipality of Cuernavaca (Figure 2).

A similar strategy was followed to produce a predictive model for Jiutepec (López Varela *et al*., 2007), taking into consideration five thematic layers: i) relief (layer converted to a 25 m grid of pixels, classified grid based on three categories of agricultural field use, reclassifed values from 0 to 255, 5 to 127, and 10 to 1); ii) soils (layer converted to a 25 m grid of pixels, classified grid based on three categories of soil fertility, reclassifed values from 3 to 255, 2 to 127, and 1 to 1); iii) rivers [continuous grid based on the proximity of rivers, values within a 0 to 255 range (highest value indicates proximity to rivers)]; iv) drainage [continuous grid based on the proximity of hypothetical drainage systems, hypothetical drainage systems calculated by the digital elevation model (DEM) reclassified to 25 m pixels, calculated drainage based on a hierarchy of 3]; v) slope [continuous grid based on slope values, hypothetical slopes calculated by DEM reclassified to 25 m pixels, values within a 0 to 255 range (highest value indicates less slope)]. All variables were scaled to 8 data bits with a range scale of 0 (low) to 255 (high).

The resulting model (Figure 3) consists of five layers with the following values: relief+soils+rivers x. 05+drainage x. 05+ slope. The model was calculated by the addition of these five layers and reclassified in 10 intervals of equal classes and then recoded to a scale between 1 (low) and 10 (high). To validate the model, the location of the identified archaeological sites by the local historian of Jiutepec was compared to the resulting model. These visited sites correlate to the areas of greater sensitivity having a value of 8 or more.

The resulting models for both municipalities, certainly, are not statistical, nor can we quantify their predictive power. As planning tools, though, they have tremendous utility to guide infrastructure development towards areas that are less likely to have archaeological sites. The models are a place to start and can be refined iteratively through use, as sites are reported, or with the use of better site data layers.

Archaeological solutions for building better futures

Incorporating archaeological solutions for land-use planning shape a new way of thinking for managing the ideal cities of the future. In

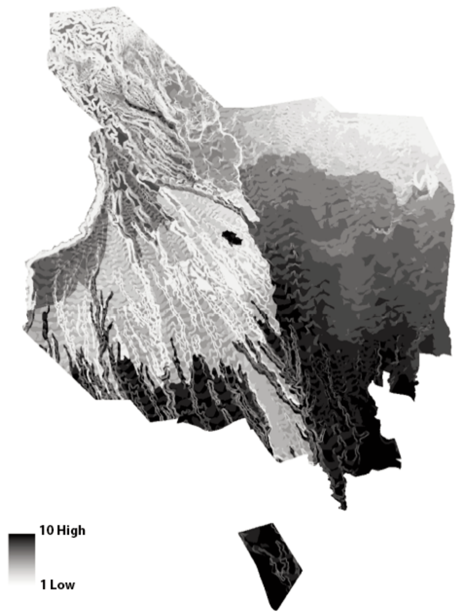

Figure 2. Predictive model for the Cuernavaca, showing sensitive areas for finding cultural resources. Courtesy of Statistical Research for the municipality of Cuernavaca, Mexico.

Figure 3. Archaeological potential model showing the probability of finding sites in Jiutepec, characterised by a densely built area. Courtesy of Statistical Research for municipality of Jiutepec.

Mexico, the use of environmental sustainable principles holds great potential as a concept for incorporating heritage values, if only clearly mandated by law and the databases could be easily be available to planners. In the absence of better data, the models are far from being robust, but at least this include the perspectives of a sampled population that will help these municipalities to balance heritage preservation with planning and development.

Although limited in application, the processes for heritage compliance were designed and incorporated in the planning process. Basically, if the developer or the citizen wants to remove a building for a new construction, an official permit needs to be issued by the municipality. The person of concern would have to provide a report documenting the style, value, physical condition issued by a registered professional, who would verify that the building is not part of the registered list of heritage resources. The applicant would submit the report to INAH to obtain a certificate of relevance. If the building has no value in terms of its heritage the municipality will the construction permit and allow the demolition of the building. If the building expresses heritage value, but, the new construction would be of more benefit to the citizens of the municipality, INAH would require from the developer to document the building before granting the permission and financially compensate INAH. If INAH decides the building expresses a high heritage value, the permit is denied. The compliance process is limited because the legislation would have to change to allow the development of a cultural resources management industry, under the oversight of government agencies and the polluter pays principle (PPP) already in place for the protection of natural resources. The inclusion of the private sector will not threaten the authority or mandate of INAH to preserve Mexico's heritage – it will simply enhance the institution ability to fulfill its mission, as the experience is proving with its granting concessions to the private sector to safeguard the nation's patrimony.

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