Journal of Archaeological Science 39 (2012) 2908–2920

Contents lists available at SciVerse ScienceDirect

Journal of Archaeological Science

journal homepage: http://www.elsevier.com/locate/jas

Don't abhor your neighbor for he is a pastoralist: the GIS-based modeling of the past human–environment interactions and landscape changes in the Wadi el-Hasa, west-central Jordan

Bülent Arıkan*

Research Center for Anatolian Civilizations, Koç University, İstiklal Caddesi No: 181 Merkez Han, Beyoğlu, Istanbul 34433, Turkey

A R T I C L E   I N F O

Article history:
Received 19 September 2011
Received in revised form
10 April 2012
Accepted 14 April 2012

Keywords:
GRASS
Landscape modeling
Anthropogenic impacts
Extensive agropastoralism

A B S T R A C T

Recently developed modules in GRASS GIS combine a wide variety of spatial data such as climatic, geological, and cultural in order to estimate how long-term interactions among these factors contribute to the evolution of natural environment and anthropogenic landscapes. Additionally, these modules allow users to visualize anthropogenic impacts of extensive agropastoralism on landscapes by subjecting the pre-defined catchment areas to repeated land use activities. The results emphasize the economic and ecological value of extensive agropastoralism in the marginal landscapes, which make anthropogenic activities more sustainable in the long-term. The results of this research are not only significant for its methodological contributions in anthropological archaeology but also have broader significance for researchers interested in interdisciplinary approaches in assessing the long-term dynamics of human-environment relations.

"*The only thing new in this world is the history that you don't know.*" Harry S. Truman, 33rd President of the United States of America (1884–1972).

1. Introduction

The continuing scholarly debates about global climate change along with current political and economic discussions about the massive scale and wide variety of anthropogenic impacts on the ecosystem have amplified interest in human-environment interactions. Archaeology has a significant role in interdisciplinary research projects since it integrates diverse analytical methods with broad intellectual background to contextualize complex human adaptive behavior at large spatio-temporal scales (van der Leeuw, 2000; van der Leeuw and Redman, 2002; Fisher and Feinman, 2005). Archaeologists can build theoretical frameworks to assess how past human behaviors and decision-making processes changed over time by combining both archaeological and environmental data. These frameworks are then used to assess the impacts of land use and resource procurement patterns in the context of past human-environment dynamics in addition to a more comprehensive evaluation of the emergence and evolution of socioecological systems.

Paleoenvironmental reconstructions have been the essential method of such projects (van der Leeuw, 1998; Peeples et al., 2006; Barton et al., 2010a,b) to illustrate the multi-dimensional, dynamic aspects of human–environment relationships that also contribute to changes in the political and economic organization of societies at large temporal scale. Besides laying out both the intended and unintended consequences of anthropogenic activities (e.g., deforestation, erosion, salinization), the study of past human impacts have the potential to shape the current and the future policies in order to: (1) create a more sustainable human–environment relationship, and (2) prevent major environmental catastrophes due to anthropogenic impacts, which would directly affect the survival of civilizations. The Central Arizona-Phoenix Long-term Ecological Research Project is an example of how the interdisciplinary researches on the past land use practices and decisions can be used to shape the current and future policies related to environment (also see Shrestha et al., 2012).

In this article, I focus on two related questions about reconstructing past environmental changes and human-environment interactions in the context of marginal landscapes of the southern Levant: (1) what are the impacts of changing climatic conditions towards hyper-aridity after 4400 BP on the environment, based on long-term variations in the rates of sediment erosion-deposition, and (2) what are the impacts of anthropogenic activities (i.e., extensive

* Tel.: +90 212 393 6101.
E-mail address: bulent.arikan@gmail.com.

0305-4403/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jas.2012.04.051

agriculture and pastoralism) on the succession rates and patterns of land cover in the arid zones of the southern Levant, and how such land use patterns contributed to long-term changes in landscape as result of varying types and intensity of human activities.

This research presents a new analytical tool for studying the impacts of both natural changes and human impacts on landscapes combining archaeological data, between the Chalcolithic and the Iron Ages (ca. 6500–2500 BP) from the semi-desert Wadi el-Hasa (Hasa hereafter) drainage in west-central Jordan (see Section 2.3), and the output of the Macrophysical Climate Modeling (MCM hereafter, see Section 3.1). Although the discussion is centered on the early metal ages of the southern Levantine drylands, the method of computational modeling for long-term landscape changes can be replicated in other regions, as long as crucial climatic and geological variables are known with some level of accuracy (see Section 3 for detailed discussion). On the other hand, the reader should refer to Bryson and DeWall (2007), Barton et al. (2010a,b), and Ullah (2011) for more information about the geoscientific aspects of the geographical information systems (GIS hereafter) methods used since the discussion is not focusing on these topics. The readers are encouraged to compare the results from Ullah (2011) and this research as the former uses the same methods of computational modeling in the Wadi Ziqlab of northern Jordan, which has different climatic and land cover characteristics than the Hasa.

2. The environmental and cultural background

2.1. The paleoenvironment of the Levant

In the discussions of prehistoric economic organization and ancient human impacts on environment, paleoenvironment stands out as the natural context of adaptive behaviors. In archaeology, there wide variety of methods that reconstruct prehistoric climate and environment using proxy data. Only when the archaeological evidence is combined with such reconstructions, it is possible to illustrate the dynamic relationship between the culture, its environment, and anthropogenic impacts on environments through time. The Levant has a long history of paleoenvironmental research using speleothems (Bar-Matthews et al., 1999), paleogeomorphology (Mabry, 1992), and paleolimnology (Frumkin, 1997; Bowman, 1997).

Palynology contributes to the study of past climates in a more indirect way: the assessment of climatic conditions through the reconstructed plant communities and their known environmental requirements. Although there are numerous case studies that cover hundreds of thousands of years of the environmental history, the most relevant examples related to the drought in the early metal ages will be used here. The first palynological research that provide evidence for late third millennium B.C. climatic oscillations, which may have contributed to the collapse of the Early Bronze II–III urban system in the Early Bronze IV in the Near East, comes from Horowitz's (1971, 1974) cores from Hula (K-Jam, U.P. 6 and U.P. 15) and Kinneret (D-1016/2) basins. In a more recent study of the pollen cores from the west side of the Jordan Rift Valley, Horowitz identifies a zone (i.e., Q-10: 11 Kyr to present) where a warm, dry interval roughly corresponds to the Early Bronze IV (Horowitz, 2001: 612).

Baruch's research is significant since the data bear the earliest signs of anthropogenic impacts (i.e., of especially horticulture and grazing) on the environment during the late Neolithic, which gradually intensify through the Chalcolithic and the Early Bronze, and eventually lead to the degradation of forests (Baruch, 1989: 292). This contributes to severe erosion due to cultivation, grazing and burning especially during the third and second millennia B. C.

Hunt et al. (2007) combine palynological data with geomorphology and geoarchaeology in order to illustrate the scale and the extent of climate change during the Holocene between the hyper-arid Wadi Arabah and the Mediterranean woodland in the uplands of Edom. Although the main focus of authors is on the environmental impacts of mining and smelting copper ores in the region, their discussion provides important clues about how intensive use of resources changed the landscape along with natural, climate-driven changes in the environment (Hunt et al., 2007: 1329–1330). Considering the long-term patterns in the vegetation history, Hunt et al. suggest that climate between the early and middle Holocene is wetter, which then turns arid in the Early Bronze Age (2007: 1332). These changes in vegetation from the early to the middle Holocene are well documented in other regions of the Near East and seem to have contributed to the emergence of a completely different landscape (i.e., incised wadi floors) and biota (i.e., steppe, desert) (Hunt et al., 2007: 1332).

Finally, Neumann et al. (2010) focus on a 75 km long transect along the western Dead Sea shore to study the palynological and sedimentological data in order to provide a detailed outline for the climatic fluctuations for the last 3500 years, using the vegetation history. Using the results from six cores, the researchers argue that the drop in the lake level and the low percentage of arboreal pollens during the Late Bronze Age indicate arid climate patterns, which last through the Iron age in the region (Neumann et al., 2010: 760–761).

2.2. The environment of the Hasa

The Hasa (Fig. 1) is the southernmost fluvial system in Jordan that drains into the Dead Sea, carving its way through marls and limestone rocks of the Upper (western terminus) Hasa to the Lower (eastern terminus) Hasa where talus deposits and extensive alluvial terraces have been identified (Schuldenrein and Clark, 1994, 2003). The drainage, which has highly dissected and varied topography, is bounded by the Arabian Desert on the east. The Karak Plateau, a geologically more stable region with thicker soil profiles and higher precipitation is to the north and the Edom Plateau is to the south of the Hasa (Fig. 2).

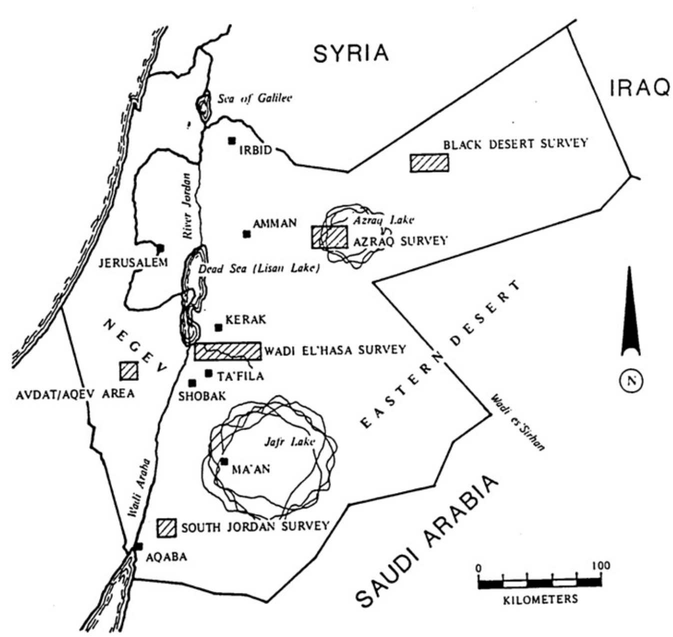

Fig. 1. The map of the Hashemite Kingdom of Jordan showing the location of the Wadi el-Hasa in relation to Amman, the Dead Sea and the Gulf of Aqaba (with permission, from Clark, 1998: 78).