∎KENYA

Prehistoric Land–use in the Loita–Mara Region, Southwest Kenya: A Preliminary GIS Site Catchment Analysis

Oula Seitsonen
Department of Archaeology
University of Helsinki
PO Box 59, FI–00014 University of Helsinki, Finland
Email: oula.seitsonen@helsinki.fi

The use of Geographical Information Systems (GIS) for the study of archaeological settlement pattern and land-use studies have been underrepresented in East African archaeology, until recently (Causey 2005; Causey and Lane 2005; Ndiema 2006). Today there is inexpensive (or even free) GIS software and GIS data from various parts of Africa thanks to co-operative projects of different organizations. This material provides an excellent and easily accessible starting point for a variety of GIS analyses. For detailed descriptions of the foundations of SCA, the reader is referred to Vita-Finzi and Higgs (1970), Hunt (1992) and Kvamme (1999). For critiques of SCA and Optimal Foraging Theory on which SCA is based, see Hodder and Orton (1976: 233–236), Gaffney et al. (1996), and Wheatley and Gillings (2002: 159).

SCA studies that were previously carried out in Kenya (e.g. Causey 2005; Robertshaw and Collett 1983) and elsewhere in Africa (e.g. Sinclair et al. 1993; Taruvinga 2001), were large but unexpectedly sparse. In this brief paper I present a preliminarily GIS site catchment analysis (SCA) for archaeological sites in the Loita–Mara region, SW Kenya (Figure 1). Data is also drawn from a large archaeological project directed by Dr. Peter Robertshaw (Robertshaw et al. 1990), which located a large number of new archaeological sites in this area in the 1980s (Figure 1), and from the field notes stored in our department of our late professor emeritus, Ari Siiriäinen, (Department of Archaeology, University of Helsinki) (Siiriäinen 1990).

In an early Kenya study by Robertshaw and Collett (1983), SCA was demonstrated to be a useful tool for estimating cultivation possibilities in the vicinity of archaeological sites. Specifically, Robertshaw and Collett suggested that many Pastoral Neolithic (PN) sites are commonly placed next to soils with a high cultivation potential. This observation might suggest a mixed agro–pastoral livelihood, at least for parts of the PN period (see also Ambrose and DeNiro 1986; Marshall 1990; Robertshaw 1990). A preliminarily evaluation of this hypothesis is the focus of the study presented below. Based on published data (Robertshaw et al. 1990; Simons 2003), and the field notes stored in the British Institute in Eastern Africa and in our department, I used a large site sample to test the hypothesis that there a correlation exists between PN sites and good agricultural land. Included in the sample were all of the locations reported by Robertshaw and others from the Loita-Mara region, including both dwelling sites and the find loci. The analyses are ongoing, and in the future other spatial issues will be reviewed more closely.

Environmental GIS data for the analyses was acquired from various providers in the World Wide Web, in particular: the International Soil Reference and Information Centre (http://www.isric.org/), the United Nations Food and Agricultural Organisation's Africover Project (http://www.africover.org/), and the International Livestock Research Institute (http://www.ilri.org/). The digital elevation model for the study area was generated with data compiled from the Shuttle Radar Topography Mission (http://www2.jpl.nasa.gov/srtm), and the Map Maker Trust (http://www.mapmaker.org/). At this stage the study area was restricted to the Kenyan side of the border (Figure 1). GIS data is usually nationwide and requires further processing and editing to be extended across the border to the Serengeti Plains.

In the current study area, the PN sites include Narosura, Elmenteitan and Akira sites, as well as those classified as "Other PN", including sites with Late Stone Age (LSA) lithics and unspecified ceramics. In addition to the PN localities, Preceramic LSA, Post–Elmenteitan, and Pastoral Iron Age (PIA) sites are found in the area. For the uniformity of the catchment data, only the sites whose maximum catchment fitted fully within the study area were included in the analyses (Table 1; Figure 2).

Agricultural potential of the study area was modelled following the FAO standards (http://www.fao.org/ag/agl/agll/gaez/index.htm). Variables

Figure 1: Digital elevation model of the study area and the known archaeological sites (based on Robertshaw et al. 1990, P. Robertshaw's field notes stored in the British Institute in Eastern Africa, and A. Siiriäinen's and O. Seitsonen's field notes in the Department of Archaeology, University of Helsinki) (map: O. Seitsonen).
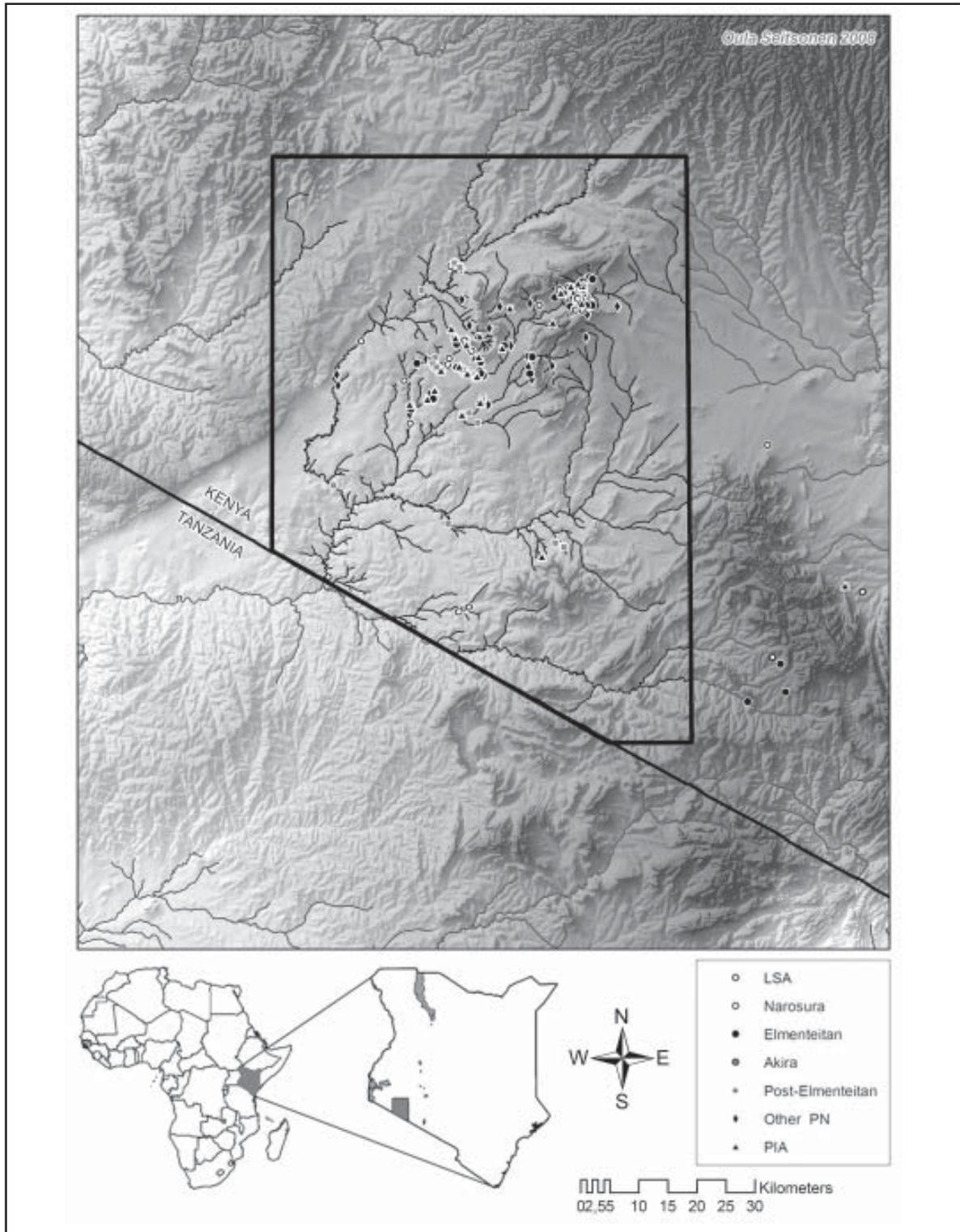
Figure 2: Left: Layers used in the modeling of agricultural potential, from the top: rooting depth, drainage, natural fertility, rainfall, gradient; Right: Spatial distribution of the agricultural potential and the archaeological sites included into the preliminary SCA. For the site affiliations, see legend in Figure 1 (map: O. Seitsonen).
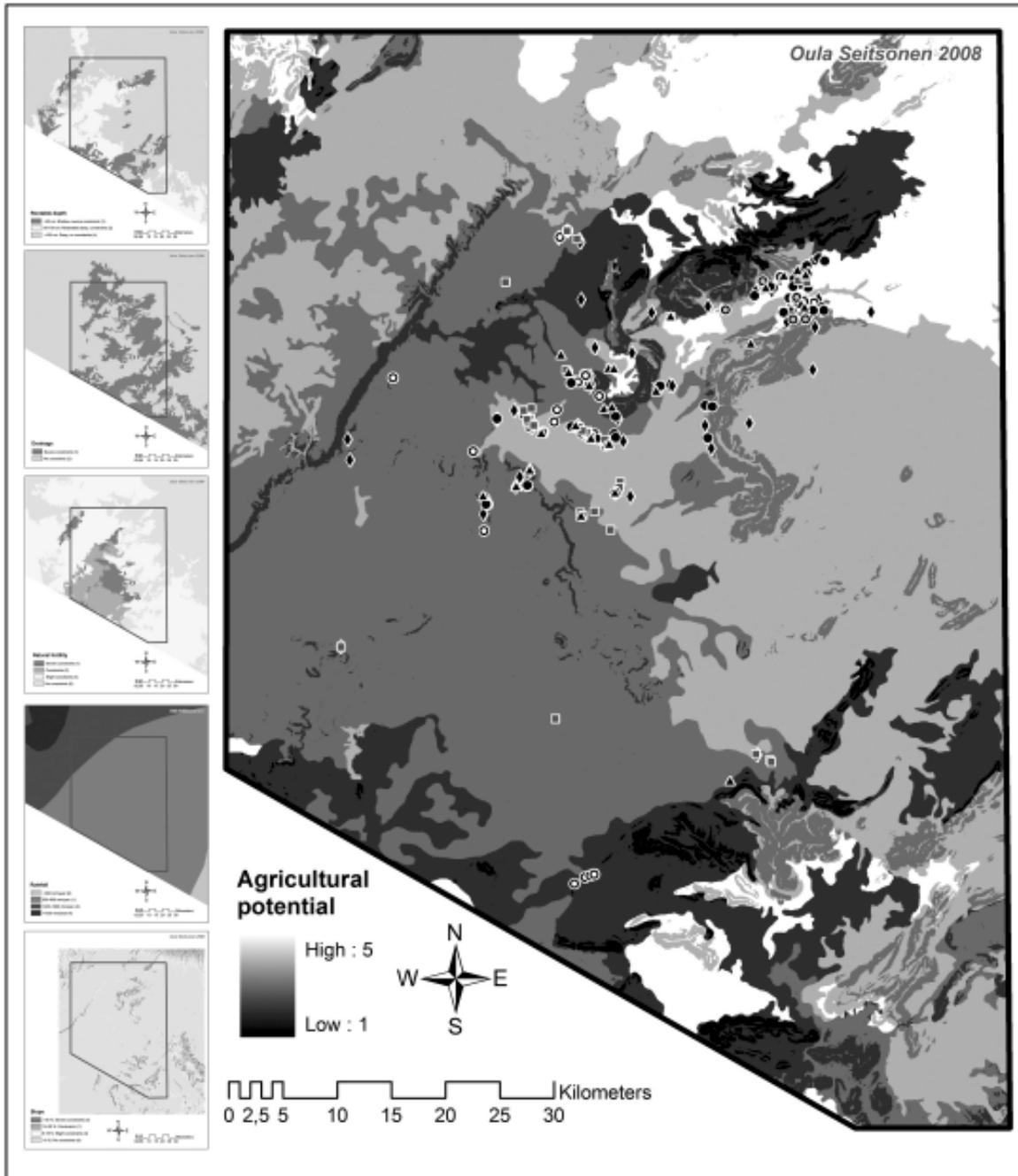
Table 1: Find locations included in the preliminary SCA.

Affiliation	N
LSA	37
Narosura	9
Elmenteitan	60
Akira	7
Post–Elmenteitan	39
PIA	31
Other PN	59
N	242
Note: Includes 33 multi–component localities	

used were: rooting depth, drainage, natural fertility of the soils, as well as rainfall and slope gradient data. Based on the combination of these variables the soils were classified into five agricultural potential (AP) classes which ranged from very good (value = 5) to very poor (value = 1) (Figure 2). All of the analyses were performed with the ArcGIS 9.3 and MapInfo 8.5 software. Details of the compiled GIS database and the analyses will be described in upcoming publications.

In this preliminary stage of investigation, the SCA was conducted using catchment areas based on Euclidean distance as was used in the original study by Robertshaw and Collett (1983). Robertshaw and Collett used catchments with a five kilometre radius, but because of the possibilities offered by GIS, I tested circular catchments in the current study area with multiple radii up to eight kilometres from the sites (Figure 3). This distance is close to both the commonly used catchment radius for hunter–gatherer populations (10 km), as well as to the maximum herding radius (9 km) observed by Coppolillo (2000) in his ethnographic study of Sukuma agropastoralist herding practices. In the upcoming studies isotropic cost–distance catchments will be calculated for the sites. These types of catchments present better models of potential exploitation territories than do the traditionally used circular catchments because they are based on local topography, hydrology, and other selected variables (e.g. Gaffney et al. 1996; Kvamme 1999; Wheatley and Gillings 2002:152).

Percentages of the different AP classes within the catchment areas were calculated at various dis-

tances from the sites and compared with the background environment. In distances beyond the radius of five kilometres, (at least in the case of circular catchments), the percentages start to approach the background values. Importantly, even the preliminary SCA shows that the PN sites have consistently greater amounts of good agricultural land within their catchments than do either the preceding LSA sites or the following post–Elmenteitan and PIA sites (Figure 4). The latter site categories include generally the highest percentages of moderate farm land within their catchments. Soils with moderate agricultural potential provide adequate pasture land, which may be indicative of change towards specialised pastoralism during the late Elmenteitan period (cf. Robertshaw 1990). However, it should also be noted that the AP values around the "Other PN" sites differ clearly from the Narosura, Akira and Elmenteitan sites. In upcoming studies these and their correlations should receive closer attention because they might represent different activity facies of these PN traditions (Cf. Robertshaw 1990).

This brief analysis may support the observations made by other researchers regarding the association between PN sites and the high agricultural potential of adjacent soils (Robertshaw and Collett 1983). It is anticipated that differences between site categories will be even more pronounced when the analyses are completed using cost–distance catchments because cost–surface catchments leave out the arduously accessible and typically agriculturally poorer terrain. On the other hand, at this preliminary stage, observations were made on a general level and more detailed study might alter this perspective.

A more rigorous study, acknowledging the finer spatial-temporal variation in site location, site size, and find material, might reveal other spatially determined aspects. This might open up a more dynamic picture of past land–use and settlement systems. For example, this could provide one approach to evaluating the diachronic model suggested by Robertshaw (1990) for Elmenteitan economic development (see Simons 2005). In the future it seems reasonable to model land-use potential for various forms of economic exploitation, including agriculture and pastoralism (Cf. Robb and Hove 2003), in order to allow for more wide-spread comparisons.

Based on a more comprehensive study it will be possible to test the GIS predictive modelling of

Figure 3: Circular catchments (radius = 8 km) showing the agricultural potential around the LSA sites (map: O. Seitsonen).
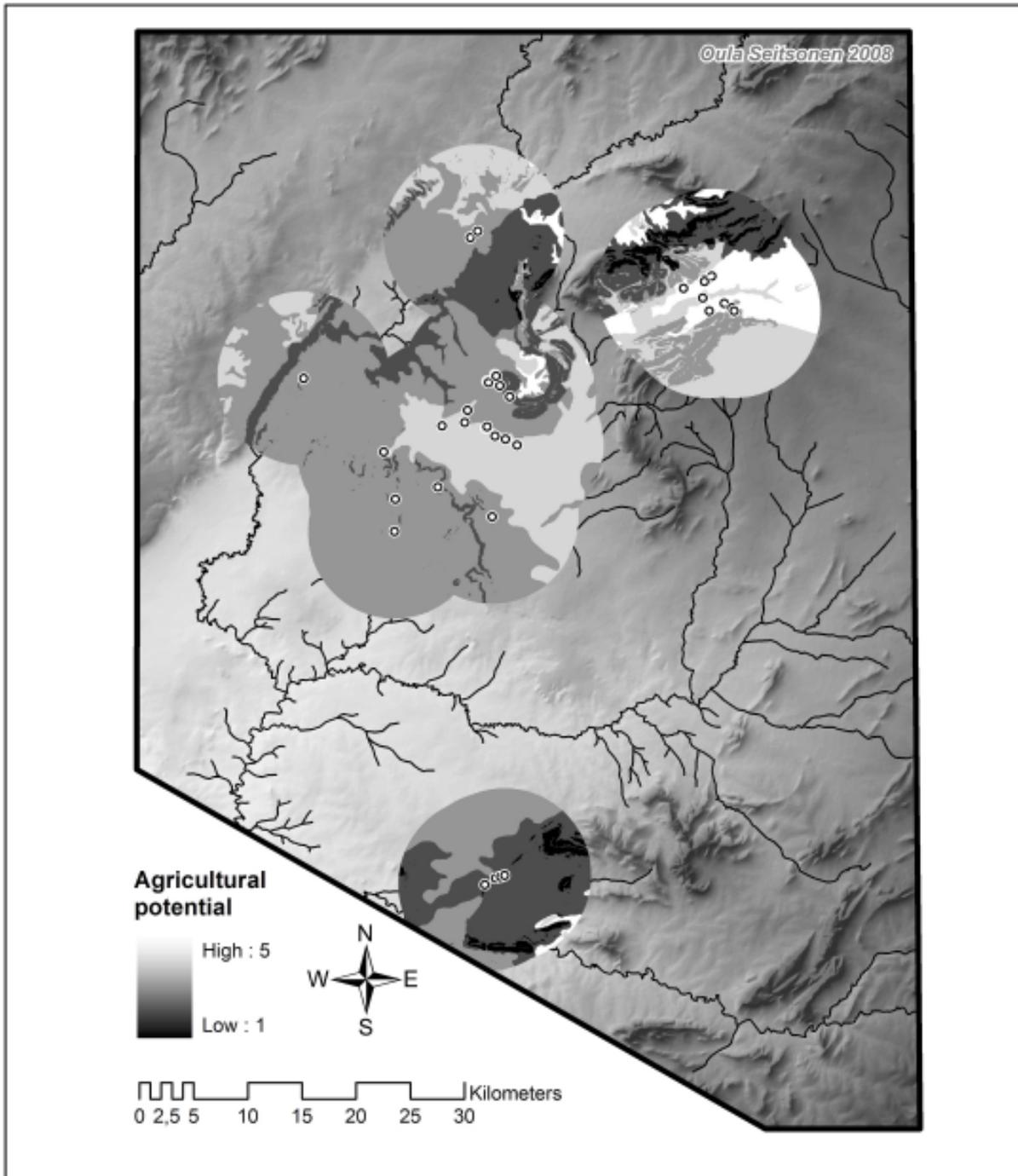
Figure 4: Deviation of the AP classes from the background values (background = 0 %) within the circular catchments with the radii of 250 m and 1000 m.
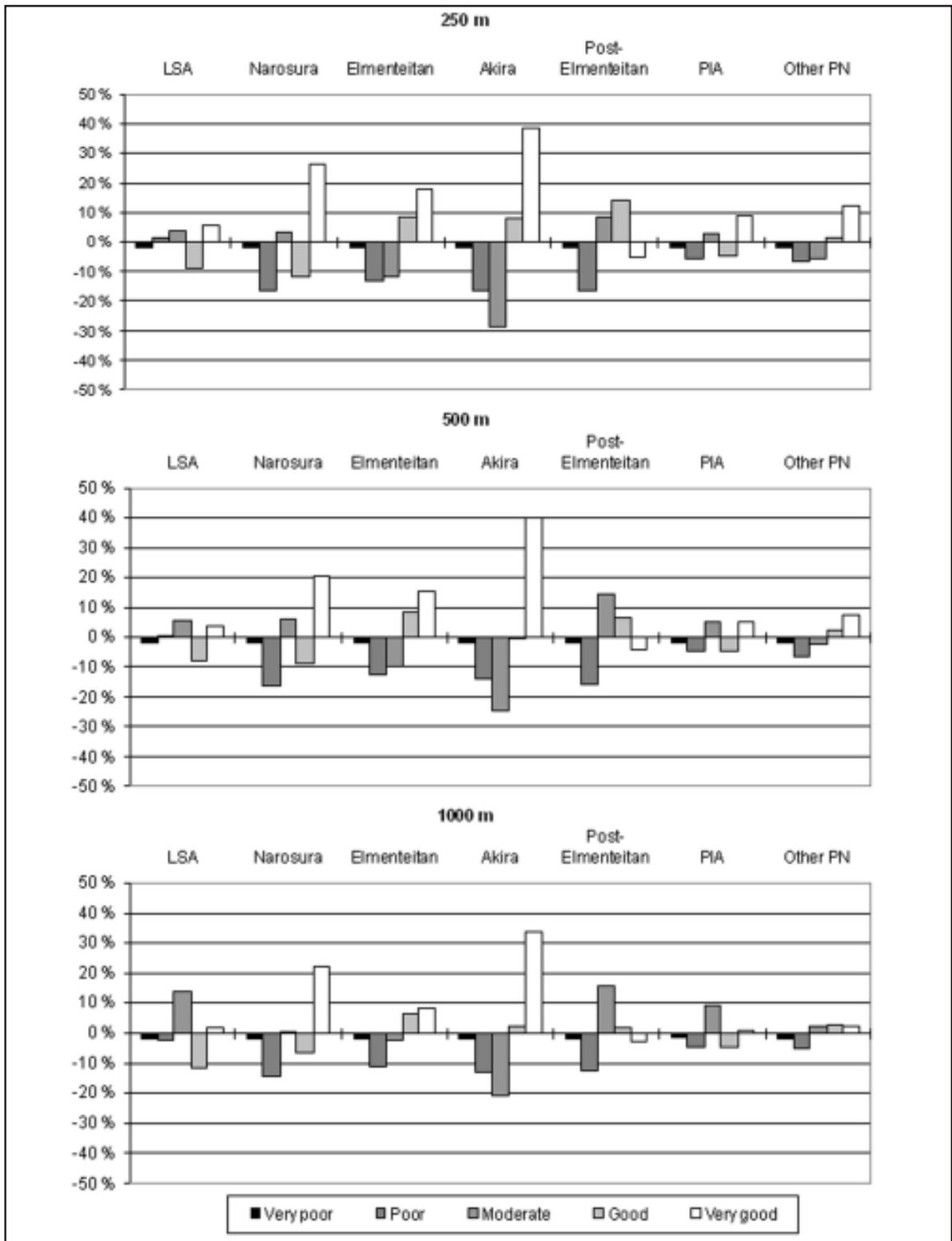
archaeological site distributions (e.g. Wescott and Brandon 2000), which have been infrequently used in East African contexts (but see Ndiema et al. 2006). In addition to contributing to archaeological research, predictive modelling could have more widespread use in planning modern pastoral land–use for example, as well as in designing sustainable development schemes.

Bibliography

Ambrose, S. H. and M. J. DeNiro

1986   Reconstruction of African human diet using bone collagen carbon and nitrogen isotope ratios. *Nature* 319: 321–324.

Causey, M.

2005   Preliminary GIS Analysis of Archaeological Sites. In P. Lane, editor, *Landscape and Environmental Change in Semi–Arid Regions of East and South Africa: Developing Interdisciplinary Approaches. Summary of Results on Laikipia, Kenya*, pp 113–120.

Causey, M. and P. Lane

2005   GIS and Landscape Archaeology: Delineating the Possible Long–Term Environmental Effects of Pastoralism on the Laikipia Plateau, Kenya. *Nyame Akuma* 64: 24–32.

Coppolillo, P.B.

2000   The landscape ecology of pastoral herding: Spatial analysis of land use and livestock production in East Africa. *Human Ecology* 28: 527–560.

Gaffney, V., Z. Stanèiè and H. Watson

1996   Moving from Catchments to Cognition: Tentative Steps toward a Larger Archaeological Context for GIS. In M. Aldenderfer and H. D.G. Maschner, editors, *Anthropology, Space, and Geographic Information Systems*. New York: Oxford University Press, pp 132–154.

Hodder, I. and C. Orton

1976   *Spatial Analysis in Archaeology.* Cambridge: Cambridge University Press.

Hunt, E.D.

1992   Upgrading site-catchment analyses with the use of GIS: investigating the settlement patterns of horticulturalists. *World Archaeology* 24: 283-309.

Kvamme, K.L.

1998   Recent Directions and Developments in Geographical Information Systems. *Journal of Archaeological Research* 7: 153-201.

Marshall, F.

1990   Cattle herds and caprine flocks. In P.T. Robertshaw, editor, *Early Pastoralists of South–Western Kenya,* Nairobi: B.I.E.A., pp 205–260.

Ndiema, E.

2006   *GIS modeling for Holocene sites, resource distribution and settlement patterns at Koobi Fora and Laikipia, Kenya*. Poster, SAfA 2006 Conference, June 22-26, 2006, Calgary, Canada.

Ndiema, E., D. Braun and J.W.K. Harris

2006   *Predictive modeling of Holocene archaeological sites from the Lake Turkana Basin, Galana Boi Formation, Kenya*. Abstract, SAfA 2006 Conference, June 22-26 2006, Calgary, Canada, available at: http://cohesion.rice.edu/Centers AndInst/SAFA/emplibrary/ proceedings%20alphabetically2006.11.5.doc

Robb, J. and D. Van Hove

2003   Gardening, foraging, and herding: Neolithic land use and social territories in Southern Italy. *Antiquity* 77: 241-254.

Robertshaw, P.

1990   Early pastoralists and their herds in the Loita–Mara region. In P.T. Robertshaw, editor, *Early Pastoralists of South–Western Kenya,* Nairobi: B.I.E.A., pp 293–302.

Robertshaw, P. and D. Collett

1983   The identification of pastoral peoples in the archaeological record: an example from East Africa. *World Archaeology* 15: 67–78.

Robertshaw, P., T. Pilgrim, A. Siiriäinen and F. Marshall

1990   Archaeological surveys and prehistoric settlement patterns. In P.T. Robertshaw, editor, *Early Pastoralists of South–Western Kenya,* Nairobi: B.I.E.A., pp 36–51.

Siiriäinen, A.

1990   Excavations of Elmenteitan sites in the Olodorotua Valley. In P.T. Robertshaw, editor, *Early Pastoralists of South–Western Kenya,* Nairobi: B.I.E.A., pp 261–266.

Simons, A.

2003   Sugenya: a Pastoral Neolithic site in south–western Kenya. *Azania* 38: 169–173.

2005   Exchange networks, socio–political hierarchies and the archaeological evidence for differential wealth amongst Pastoralists in south–western Kenya. *Nyame Akuma* 64: 33–35.

Sinclair, P., I. Pikirayi, G. Pwiti and R. Soper

1993   Urban trajectories on the Zimbabwean Plateau. In T. Shaw, P. Sinclair, B. Andah and A. Okpoko, editors, *The Archaeology of Africa. Food, Metals and Towns.* London: Routledge, pp 705–731.

Taruvinga, P.

2001   GIS and archaeology: A spatial analysis of rock art sites in Matopo Hills. In F. Chami, G. Pwiti and C. Radimilahy, editors, *People, contacts and the environment in the African past* (Studies in the African past 1). Dar es Salaam: University of Dar es Salaam, pp 168–175.

Vita-Finzi, C. and E.S. Higgs

1970   Prehistoric Economy in the Mount Carmel Area of Palestine: Site Catchment Analysis. *Proceedings of the Prehistoric Society* 36: 1–37.

Wescott, K. (in the front cover erroneously "Westcott") and R.J.Brandon

2000   *Practical Applications of GIS for Archaeologists: A Predictive Modeling Toolkit.* London: Taylor & Francis.

Wheatley, D. and M. Gillings

2002   *Spatial Technology and Archaeology: The Archaeological Applications of GIS.* London: Taylor & Francis.