Landscape archaeology: Simulation of vegetation models

Case study for the middle Wadi Abu Dom in the post-meroitic period

Motivation and Introduction

The climate crisis is the greatest challenge facing humanity. Archaeology, with its knowledge of past relationships between human settlement structures and flora and fauna remains, can make an important contribution to the modelling of vegetation. These vegetation models not only allow us to understand the living context of this historic site. They also offer the possibility of renaturalising the site and making the living context more tangible for visitors. In this way, archaeology can also contribute to the climate crisis through targeted restoration projects. In this way, jobs can be created around historical sites in plant and tree care and renaturation.

The Middle Wadi Abu Dom (Sudan) in the Post-Meroitic period will serve as a specific example in this work.

Methodology: Theory and Related Work

Diachronic land cover modelling, mainly used in landscape ecology (Verstegen, Karssenberg, van der Hilst and Faaij, 2016), has also become quite common in recent landscape archaeological research (e.g. Eger-Karberg and Karberg, 2024; Karberg, 2021). However, visualisations of these models are often rather abstract and less intuitive. The vegetation visualisation model presented in this paper fills this gap and simulates qualitative and quantitative vegetation patterns based on basic parameters such as DTM (JAXA Earth Observation Research Center, 2022), soil mapping (Jones, et al., 2013) and the diachronic climate model PMIP 3 (Fordham, et al., 2017). The model is programmed in Java and calculates the probability of the presence of three exemplary plant species (acacia, grass, sorghum) according to soil quality, the presence of surface water and the slope of the terrain, also derived from the DTM. The visualisation of the plants is modelled in Blender 3.6.

Data Recording and Process Workflow

The probability value of plant occurrence in each pixel is derived from the 'ALOS World 3D 30m' model provided by JAXA, and metrically scaled estimates of the fertility and water permeability of the different soil types, and the availability of surface water either from direct precipitation derived from the PIMP 3 climate model (accessed via PaleoView 1.5) or from surface water concentrations reconstructed using the DTM-based 'Deterministic 8' drainage model (O'Callaghan and Mark, 1984). 5) or from surface water concentrations reconstructed using the DTM-based 'Deterministic 8' drainage model (O'Callaghan and Mark, 1984) calculated using the 'Channel network and drainage basins' tool of the SAGA 9.4 geoscience analysis toolbox.

As training data, recent vegetation cover of the middle Wadi Abu Dom is used. This is derived from data acquired by the Wadi Abu Dom Investigations project between 2013 and 2016, especially high-resolution DSM and orthophotos derived from UAV imagery using Agisoft Photoscan 1.4.5 (Karberg and Lohwasser, 2018, pp. 18-19).

As exemplification of the modelling, the vegetation is calculated for two 10-year time slices: 1975-1984 AD and 201-210 AD. The 1975-1984 time slice is intended as a functional test of the model. It differs by chronological means sufficiently from the training data, but the result of the modelling can still be compared with reliable earth observation data, which is available from 1972 onwards from the satellites of the Landsat series. Plant species distribution patterns and overall vegetation density calculated by the model are compared with normalised vegetation indices (Tucker, 1979) derived from Landsat 4 and 5 multispectral data (Short, 1982) calculated using the QGIS 3.36 raster calculator. The second exemplification modelling is for the time slice from 201-210 AD, contemporary to the first construction and use phase of the settlement site of El Tuweina in the middle Wadi Abu Dom (Eger and Karberg 2023, p. 607). It is intended to visualise the vegetation cover of the landscape this settlement was embedded in.

Conclusions and Future Work

The plan is to make all the data recorded, the workflow and the final model freely available as a study object. Work is intended to be continued within the framework of a planned research project at HTW Dresden focusing on the interaction of historic non-sedentary ethnic groups with their natural and socio-ecological environment, including diachronic landscape and land use modelling. The tool and workflow presented here is planned to be integrated into this project as a visualisation tool for the comprehensive land use and land cover modelling.

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