Model-building and research implications of an open source GRASS GIS approach:
Dealing with reliability and comparability of off-site landuse models

(1) This paper aims at evaluating, first how the use of spatial technologies can contribute to the understanding of long term off-site activity and second how we can deal with methodological issues in testing and comparing GIS-based models.

(2) For this purpose I will present a case study in the framework of a comparative project in landscape and computational archaeology, aiming at studying long term agro-pastoral landuse, seasonal practices of movement and integrated strategies of resource exploitation from the neolithic to the modern time in mountain environment. A special focus of the project is on the understanding of the interconnection of intensive exploitation in the plain and subsistence economy in marginal landscapes. Case studies are considered in the Mediterranean and South-West-Alpine region.

(2.1) The first sub-project considers a sample-microregional context in the Valais canton of Switzerland, by inquiring **(3)** the plain-middle altitude-high altitude transect of the val d'Hérémence, a transversal N-S oriented corridor of the Rhone Valley characterized by an average elevation of 2.500m, ending at the bottom of the Grand Dixence Dam. A first systematic fieldwork campaign - extensive and where possible intensive survey - have been carried out in August 2009 in collaboration with the Cantonal Museum of Sion in an area of about 20kmq. **(4)** The survey aimed at testing and integrating existing information about middle altitude multi-phase permanent agro-pastoral settlements, high altitude seasonal pastoral buildings and productive infrastructures and transhumance-related paths. **(5)** The evidence of the post-medieval and modern time has been identified and recorded **(6)** by topographical survey: **(7:pointer)** modern exploitation has been compared to the patterns of building ruins and enclosures and to the archaeological data.

(8) The project necessarily deals with spatial information and its comparative aims imply the need to work in a reproducible way. The lack of archaeological information and the bad visibility conditions affecting an alpine landscape because of erosion-deposition processes and landuse can take advantage from the use of theoretical computational models, providing a base for the evaluation and interpretation of the weak archaeological evidence. Questions related to spatial organization, site catchment and movement can be addressed with the support of GIS technology allowing us to visualize, overlay, cross and quantifying geo-environmental and socio-economic parameters. The database incorporates the variables related to elevation, geology, geomorphology, hydrology.

The adopted model is raster-based and consists in a first stage of the creation of cost surfaces, representing the cumulative cost of movement from one point on a map as input. This is a very

common approach to the reconstruction of territories and movements and has been applied in this context in order to model least cost paths related to the seasonal vertical transhumance movement.

Raster-based GIS models have on one hand analytical, explorative and interpretative potential; on the other hand methodological limitations and the risk of generating inconsistent models have to be considered. Conditional cell-based surfaces contain different information incorporating environmental as well as cultural constraints and landmarks. An iterative and heuristic procedure can reduce the problems of raster models, while changing locally defined parameters allows to make models reproducible.

(9) In order to create a diachronic model of the resource exploitation and mobility at a micro-regional scale, the data concerning this area have been imported in GRASS GIS and analyzed using raster modules and running bash-shell scripts for linking and iterating processes.

First a digital terrain model has been created by elaborating LIDAR raw data in ASCII format at 2m resolution. **(10)** Starting from the digital terrain model the relevant topography-based factors have been generated and maps of the isotropic as well as anisotropic cost of movement has been created from slope terrain costs. The topography-based site catchment around the site describes the accessibility to the territory as a base for the model to be implemented. Area statistics of geomorphometric influencing factors in the defined boundaries of the calculated catchment can be extracted.

(11) The generated cost surfaces as well as site catchment are used in a further stage as a basis for running models aiming at simulating high mountain pastoral and middle mountain agro-pastoral landuse. The GRASS module r.pastoral.simple creates a series of iterative pastoral landuse maps from a catchment created by r.catchment**.**. Parameters to set to run iterations (“years” of exploitation) are: percent of area to be grazed in any year, size of grazing patches, intensity of grazing (amount by which landcover is decreased after grazing). However this model does not take pastoral ecology or economy into account.

(12) The plain and middle altitude agropastoral exploitation has been simulated using the r.agropast module. The modeling steps can be resumed as follows: friction costs representing topography-based activity radius have to be calculated; the starting biomass (kg/ha/year) values for the modeled environment (grassland, shrubland, and woodland), the average amount of forage consumed by one animal as determined by herd structure and herd animal ecology, the number of herd animals to have graze, the ratio of sheep to goats as well as intensity of grazing can be set. This application can to be run as a support of the interpretation of off-site activity per each attested phase. The parameters influencing the simulations results need to be implemented at a local scale. The modern landuse and a punctual palaeo-environmental dataset have been used as reference input for the analysis of the

archaeological information. According to the literature, in this region the Bronze Age reveals a strong demographic development indirectly linked to the exploitation of copper deposits. Later, the mountain passes played an increasingly important role and the evolution of the economic management of the vegetation belts led to the establishment of permanent settlements during the Iron Age. The situation appears to stabilize in the Roman time, intensifying in the Medieval time.

The model of the modern and contemporary subsistence economy attests an intensive exploitation despite of a very fragile environment and unfavorable climatic conditions; according to archive sources of the XVIII c. the population growth where the same in mountainous areas as in the Rhone plain. Given the conservative character of this micro-region until the Second World War, archive and ethnographical information related to size, land division and exploitation of modern settlements have been considered as reference model parameters. This simulation can be used for the evaluation of the potential of the area, analysis of intensity of exploitation and measurement of sustainability of an economic system.

(13) The potential of a theoretical model is related also to its reproducibility and implementability: If we consider reproducibility as a requirement for comparability and comparative interpretation of the results, we need to assess criteria to be applied to different contexts and to elaborate scientific visualizations and analysis as an interpretive and expressive medium. A comparative inquiry with several case studies could take advantages from the modular implementable structure of the GRASS technology and from scripting procedure.