The interplay between man and the environment

Modelling the evolving hydrological response of a Mediterranean catchment

L.P.H. (Rens) van Beek[1], H. (Rik) Feiken[2], Hans Middelkoop[1], Marc F.P. Bierkens [1]

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Human-Earth interaction from the Pleistocene to the Anthropocene

- Department of Physical Geography, Utrecht University, The Netherlands, r.vanbeek@uu.nl
- Formerly at Groningen Institute of Archaeology, University of Groningen, The Netherlands; now at Cultural Heritage Agency of the Netherlands,

university of groningen

Universiteit Utrecht

Interplay between man and environment

•Increasingly, man plays an active role in the hydrological cycle;

•This modifies the storage and transport of water near the topographic surface and the resulting geomorphic work.

Thus, prolonged human activity, such as agriculture, may alter hydrological functioning and leave a persistent anthropogenic imprint.

View on the study catchment, the Contrada Maddalena (S Italy)

Objective

To determine the degree and persistence of the human imprint at the catchment scale.

Numerical experiments were performed to simulate the catchment response for a Mediterannean catchment of 15 km^2 under:

1. Naturalized conditions. i.e., without human influence;
2. Human influence, represented by evolving land use practices.

The simulations were performed for the period extending to 6000 years BP (6001-12000 Human Era) using reconstructed climate conditions using the CALEROS model.

Simulating human impacts with CALEROS

CALEROS (Calabria Erosion Model, Feiken et al., 2011) is a meso-scale landscape dynamics model. Its purpose is to simulate interacting processes and emerging patterns, including land use, conditioned by:

- Climate (including precipitation, temperature and radiation);
- Lithosphere (lithology, uplift & seismicity);
- Man (scenarios of agricultural systems).

CALEROS simulates hydrology as well as soil production, vegetation growth and sediment transport and deposition.

It is intended to be applied to upland catchments on centennial to millennial scales. The model is grid-based and the intended cell size to conform to the typical size of a stand or field (~25x25 m).

References

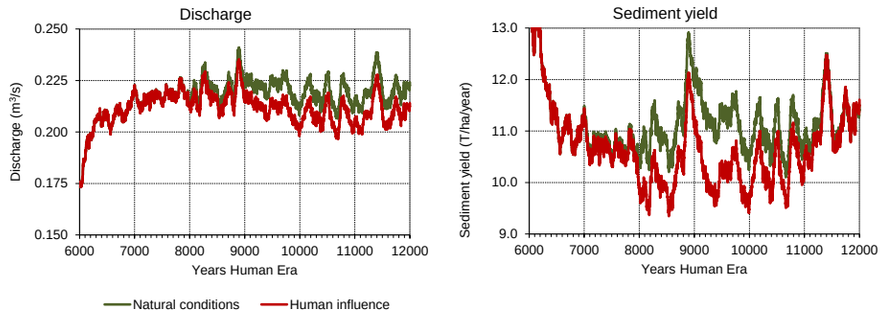
Feiken, H. , van Beek, R., van Asch, T., van Leusen, M., (2011). CALEROS: an erosion-deposition model for landscape archaeology. In Pre- And Protohistoric Landscape Studies, Siena, Italy, May 25-27, 2007, in BAR International Series 2320 2011, Oxford, pp. 13-16.

Allen, J. R. M., Watts, W. A., McGee, E., & Huntley, B. (2002). Holocene environmental variability—the record from Lago Grande di Monticchio, Italy. Quaternary International, 88(1), 69-80.

Results

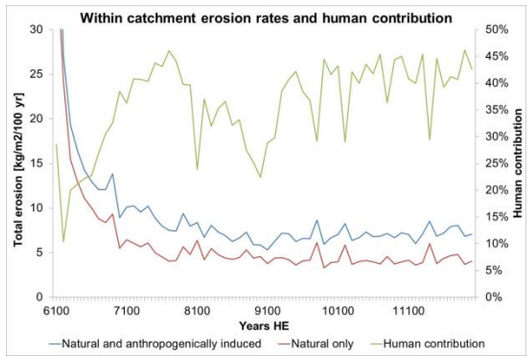
At the catchment scale, it is surprising that the lower vegetation cover due to cultivation under human-influenced conditions leads to:

- Less discharge and less sediment passing the outlet;
- Human influence becomes distinguishable soon after 8000 HE, due to detrimental slash-and-burn practices of early settlers;
- While discharge remains different thereafter, sediment yield becomes similar again after 11000.



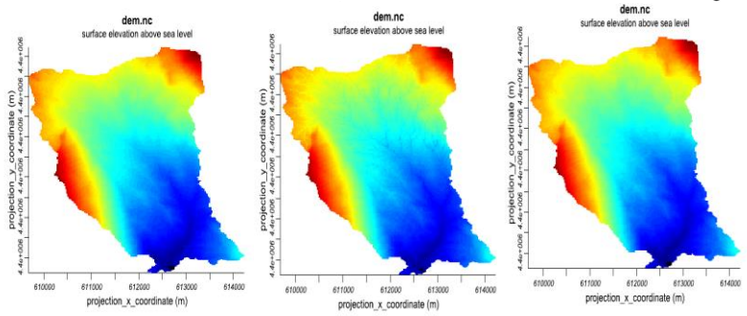
100-year running mean of simulated discharge and sediment yield at the catchment outlet. Human Era starts at 1000 years before the Common Era (e.g., 10001 HE is equivalent.to 0AD)

The signal is reversed when looking within the catchment (see below). More runoff and sediment are being produced under human-influenced conditions due to agricultural practices. However, this is largely stored internally as a result of bench terracing.

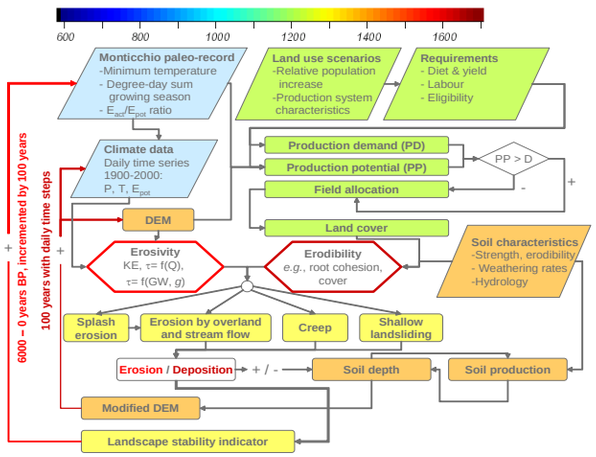


100-year running mean of simulated sediment mobilization within the catchment. Relative contribution is the additional mobilization under human-influenced condiitions. Natural erosion becomes relatively more important following earthquakes.

Changing morphology under different conditions and time steps. Under natural conditions, incision leads to a more dendritic drainage network.



Initial 6 000 HE Natural + Human | Final 12 000 HE Natural | Final 12 000 HE Human influence



Flow diagram of the different components of CALEROS and their interactions. The model is largely free to respond to the climatic forcing, earthquakes, land use scenarios and initial landscape that are imposed.

Conclusions

Simulation results show different catchment organization as a result of the interplay between humans and the environment.

Over time sediment yield at the catchment scale becomes similar again but the morphology and processes in the catchment are intrinsically different; cultivation leads to a shift from a production- to a transport-limited system.

Human influence are marked and unexpected. Judging by sediment yield at the basin-scale alone, for example using depositional records, the human impact would be underestimated in this case.