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Past soil erosion; extreme events; Middle Ages; Roman times; sustainable land use; central Europe.

Introduction

The aim of this paper is to review studies on past soil erosion in small catchments of central Europe and highlight the long-term feedback perspective of such erosion and sedimentation processes with regard to an ecosystem, including socio-economic and human impact. It is based on an earlier review paper by Dotterweich[1] but includes more recent research obtained in the past 4 years. It concentrates on the reconstruction of the long-term soil erosion history, including rare extreme events, by analysing erosional sites and colluvial deposits on foot slopes, dry valleys, and fans in small 0-order catchments pedologically as well as sedimentologically. Alluvial deposits of small tributaries and lake sediments were also incorporated. Extreme events seem to be particularly important factors, playing a key role in the evolution of past human-environment systems.[2] Such data sets are also essential to calibrate or enhance existing soil erosion models to obtain regional soil loss estimates, which are critical in creating more sustainable land use systems in changing climatic conditions, and with progressively mounting pressure to intensify land use.

Agricultural Development and Soil Erosion Processes in Central Europe

The anthropogenic transformation of European landscapes dates back to the Neolithic revolution around 7500 years ago. Since then, many phases of agricultural expansion and regression have occurred, together with associated land clearances and reforestation. As a result, in nearly all areas of Europe, the biodiversity, matter, and energy fluxes have been strongly altered by human impact.[3] This long history of anthropogenic activity had significant implications on environmental change at different scales, from the regional hydrology[4] and sediment flux[5] to perhaps global climate patterns.[6] The man-environment interaction of the past contains crucial lessons for our understanding of what constitutes environmental sustainability.[7] Conventionally, current research epitomises the history of anthropogenic activity as being characterised by resource exploitation, with climatic conditions influencing the development and functioning of societies. However, this view

1 Dotterweich 2008.
2 Costanza et al. 2007.
3 Huntley et al. 2002; Kaplan, Krumhardt, and Zimmermann 2009.
4 Macklin, Jones, and Lewin 2010.
5 Dotterweich 2008; Hoffmann et al. 2007.
6 Kaplan et al. 2010.
7 Dearing et al. 2010.

neglects non-linear change, feedback and regime shifts in human-environment systems.[8] Hence, long-term human activities and environmental change should be understood as co-evolutionary and adaptive processes.[9] A soil-geomorphological perspective has much to add to this dialogue, including an emphasis on multi-scalar viewpoints of human-environment interactions on a long-term timescale. With the clearing of the natural vegetation, the water and matter fluxes changed into anthropogenically driven systems with greatly accelerated processes and higher vulnerability to soil erosion. Repeated or extreme events triggered by climate change may have decreased the fertility of the land, partly to an extent that it could no longer be cultivated. On a local to regional scale, this may occur surprisingly rapidly, especially due to isolated but cataclysmic events. As the system develops, two outcomes are possible: a) driving forces may progress slowly, causing gradual and predictable soil degradation, or b) exceptional events may trigger catastrophic changes, forcing premature abandonment of agricultural land. Regardless of the rate of soil degradation, the system will evolve through a reorganisation phase and ultimately reach a new equilibrium, where either naturally or anthropogenically driven processes dominate the overall system.[10]

Land Use or Climate?

In the last few years, the potential of using erosional landforms and soil-sediment structures for the reconstruction of past soil erosion and colluviation has been recognised by an increasing number of studies worldwide.[11] For central Europe, several comprehensive overviews combining studies on hill slope erosion, gully erosion, and floodplain development can be found in Lang and Bork,[12] Dotterweich,[13] Dreibrodt,[14] or Notebaert and Verstraeten.[15] The observed variability of soil erosion in small catchments reflects, to a large extent, the varying intensity of population pressure and agricultural land use in Germany (Fig. 1 and Fig. 2). This is illustrated by the pronounced increase of soil erosion, particularly at the onset of and during the Neolithic period (ca. 5500–2200 BC in southern and central Germany) and by the distinctive decrease in soil erosion during the migration period (ca. 300–700 AD) and early Middle Ages (ca. 700–1000 AD).

It seems that centennial-scale climate change affected the observed variability by modifying the boundary conditions for erosion. For example, there are few erosion records from the early and middle Bronze Age (ca. 2000–1600 BC), a period known to have been a prominently dry period in central Europe. The most remarkable phase of human induced soil erosion took place in the first half of the 14th century—at the beginning of the Little Ice Age (Fig. 2). The second well-known intense soil erosion phase developed in the mid-18th to early 19th century—at the end of the Little Ice Age. Historical records document extreme precipitation events during these two phases, implying a strong influence of climatic extremes on geomorphological processes.

However, certain phases of the record remain unexplained. As a general finding, the majority of the studies on soil erosion in small catchments indicate that sediment fluxes are highly sensitive to changes in local land use, while climate change plays a secondary role.

8 Dearing 2006.
9 Holling, Gunderson, and Peterson 2002.
10 Dotterweich and Dreibrodt 2011.
11 Dotterweich et al. 2012.
12 Lang and Bork 2006.
13 Dotterweich 2008.
14 Dreibrodt et al. 2010.
15 Notebaert and Verstraeten 2010.

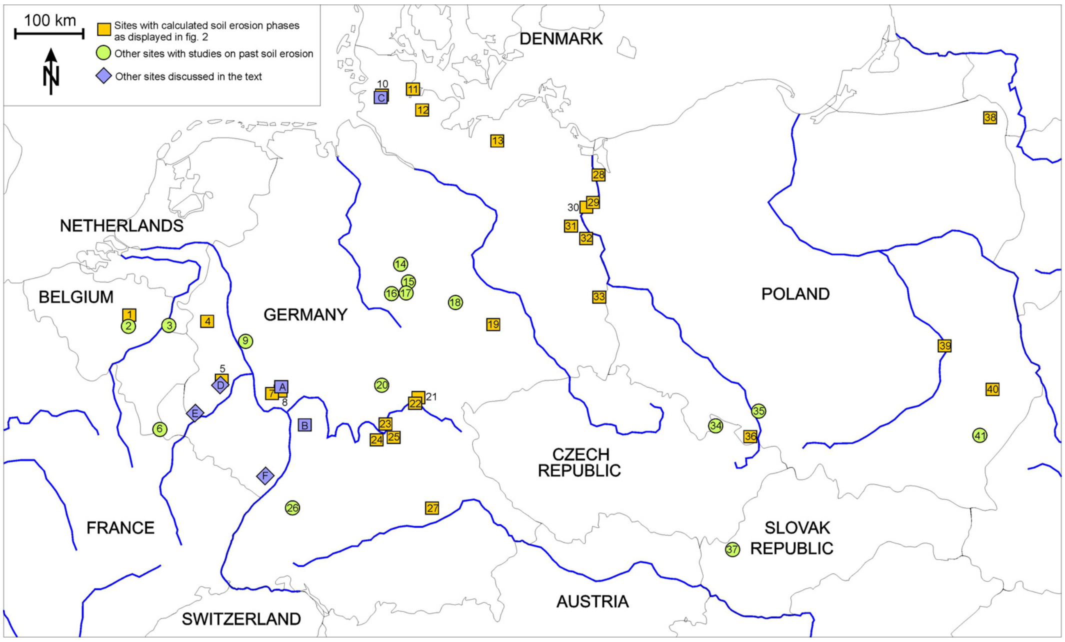

Fig. 1 | Sites where studies on past soil erosion have been carried out by different authors. The yellow and green sites have been already presented in Dotterweich 2008. More recent studies are located at Sites A Stolz 2011, B Moldenhauer, Heinrich, and Vater 2010, and C Reiß et al. 2009. Sites E and F are discussed in the text.

Human-Environment Feedback

In contrast to reconstructions of geomorphic and pedologic history, there are only a few studies concerning possible feedbacks from land use. These studies equate societal collapse with vulnerability to climate change, agricultural maladaptation or a mixture of both. For example, historical studies show that during the first half of the 14th century, many villages in Germany were abandoned as an ultimate consequence of a combination of socio-cultural processes, crop failures and soil degradation.[16] Food prices became very expensive for several consecutive years in the first half of the 14th century because of shortages resulting from soil degradation and economic mismanagement.[17] This unfavourable socio-economic, nutritional, and health situation might have prepared the ground for the European-wide pandemic, namely the Black Death, between 1347 and 1351 AD. In the 18th to early 19th centuries, soil erosion and crop failures led to major migration overseas. Soil erosion appears to have been one factor in a complex causality spiral leading to socio-economic instability and land-use changes.

Roman Times – Extreme Soil Erosion versus Sustainable Land Use?

Within the Roman Provinces, evidence of low intensities of soil erosion were found at Sites 1, 2, 5, and 26, (Fig. 1 and 2). In contrast, Löhr[18] describes extreme soil erosion as an effect of intensive land use during Roman Times (Site E in Fig. 1). In addition, north of the Limes and therefore outside the Roman territory, traces of soil erosion have been found on gentle slopes in northern Bavaria (Sites 21 and 25) and in northern Germany

16 Bork et al. 1998; Dotterweich 2008.
17 Fraser 2010.
18 Löhr 2000.

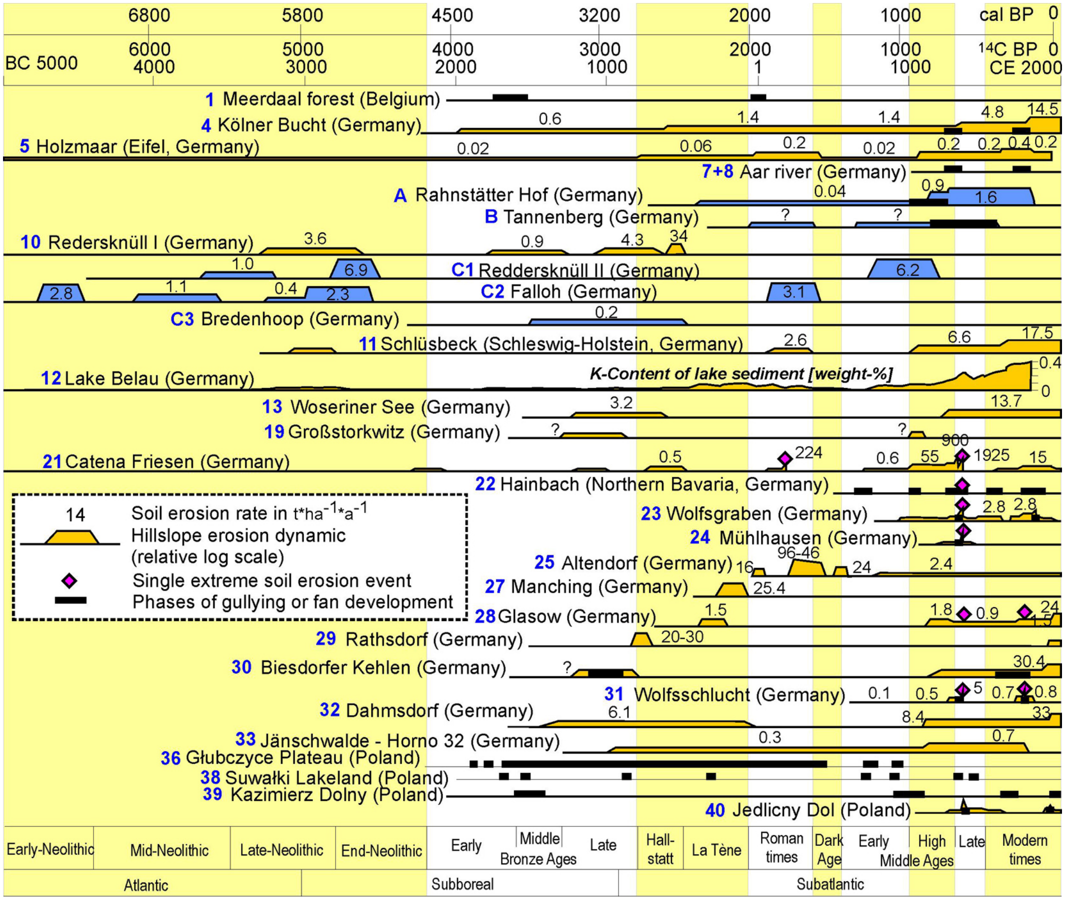

Fig. 2 | Dynamics of soil erosion in small catchments in central Europe since the beginning of agriculture, based on studies by different authors. Data sorted from east to west. Yellow background bars show different cultural epochs. Numbers correlate to study sites given in Fig. 1 (Figure modified and complemented from Dotterweich 2008).

(Sites 11, 12, and C2). Overall, soil erosion was not so high at these places, but the occurrence of single erosion events seems to be the dominant cause. Taking a closer look, the linkage between soil erosion and land use intensity during Roman Times presents a much more heterogeneous situation than in latter periods. Often, there is relatively slight indication for soil erosion unless the population density was high, and no evidence exists to suggest rather dry climatic conditions without extreme rainfall events. For example, the accumulation of sediments on a small floodplain in the eastern Eifel region (Site D in Fig. 1) shows a clear correlation with land use during the La Tène period, the Middle Ages and Modern Times. Surprisingly, the lowest sedimentation rates took place during a phase of very intensive land use during Roman Times.[19] Similar results have been found in a catchment around a Villa Rustica in the southern Palatinate (Site F in Fig. 1).[20] Traces of intensive soil erosion were found for the Middle Ages but not with regard to Roman Times. By now, it is unclear whether this is a result of different types of land use and soil conservation practices or a consequence of the small data set. Particularly the construction of small fields with lynchets or stone banks may have hindered soil erosion. There are some small-patched field systems in the Eifel region which could be ascribed to Roman Times, probably legacies of ancient sustainable land use systems.

19 Dotterweich, Wenzel, and Schreg (submitted).
20 Dotterweich et al. (in preparation).

Bibliography

Bork et al. 1998

H.-R. Bork et al. *Landschaftsentwicklung in Mitteleuropa – Wirkungen des Menschen auf Landschaften*. Gotha: Klett-Perthes, 1998.

Costanza et al. 2007

R. Costanza et al. "Sustainability or Collapse. What Can we Learn from Integrating the History of Humans and the Rest of Nature?". *Ambio* 36 (2007), 522–527.

Dearing 2006

J.A. Dearing. "Climate-Human-Environment Interactions: Resolving our Past". *Climate of the Past* 2 (2006), 187–203.

Dearing et al. 2010

J.A. Dearing et al. "Complex Land Systems: the Need for Long Time perspectives to Assess their Future". *Ecology and Society* 15.4 (2010), 21. URL: `http://www.ecologyandsociety.org/vol15/iss4/art21/`.

Dotterweich 2008

M. Dotterweich. "The History of Soil Erosion and Fluvial Deposits in Small Catchments of Central Europe: Deciphering the Long-Term Interaction between Humans and the Environment – A Review". *Geomorphology* 101 (2008), 192–208.

Dotterweich and Dreibrodt 2011

M. Dotterweich and S. Dreibrodt. "Past Land Use and Soil Erosion Processes in Central Europe". *PAGES News* 19.2 (2011), 49–51.

Dotterweich, Wenzel, and Schreg (submitted)

M. Dotterweich, M. Wenzel, and R. Schreg. "Landschaftsentwicklung seit der Römerzeit im westlichen Segbachtal bei Mayen in der Osteifel". In *Römische Landnutzung in der Eifel. Neue Ausgrabungen und Forschungen. Tagung in Mayen 3.–6. November 2011*. Ed. by M. Grünewald and S. Wenzel. RGZM-Tagungen. Submitted.

Dotterweich et al. (in preparation)

M. Dotterweich et al. "Land Use and Soil Erosion History over the Last 2000 Years in a Zero-order Catchment in the Loess Uplands of Southern Palatinate, Germany". In preparation.

Dotterweich et al. 2012

M. Dotterweich et al. "High Resolution Gully Erosion and Sedimentation Processes, and Land Use Changes Since the Bronze Age and Future Trajectories in the Kazimierz Dolny Area (Nałęczów Plateau, SE-Poland)". *Catena* 95 (2012), 50–62. DOI: `10.1016/j.catena.2012.03.001`.

Dreibrodt et al. 2010

S. Dreibrodt et al. "Historical Soil Erosion by Water in Germany: Scales and Archives, Chronology, Research Perspectives". *Quaternary International* 222 (2010), 80–95.

Fraser 2010

E.D.G. Fraser. "Can Economic, Land Use and Climatic Stresses Lead to Famine, Disease, Wrfare and Death? Using Europe's Calamitous 14th Century as a Parable for the Modern Age". *Ecological Economics* 70 (2010), 1269–1279.

Hoffmann et al. 2007
T. Hoffmann et al. “Holocene Floodplain Sediment Storage and Hillslope Erosion within the Rhine Catchment”. *Holocene* 17 (2007), 105–118.

Holling, Gunderson, and Peterson 2002
C.S. Holling, L.H. Gunderson, and D.L. Peterson. “Sustainability and Panarchies”. In *Panarchy: Understanding Transformations in Systems of Humans and Nature*. Ed. by L.H. Gunderson and C.S. Holling. Washington, Covelo, and London: Island Press, 2002, 63–102.

Huntley et al. 2002
B. Huntley et al. “Holocene Palaeoenvironmental Changes in Nort-West Europe: Climatic Implications and the Human Dimension”. In *Climate Development and History of the North Atlantic Realm*. Ed. by G. Wefer et al. Berlin: Springer, 2002, 259–298.

Kaplan, Krumhardt, and Zimmermann 2009
J.O. Kaplan, K.M. Krumhardt, and N. Zimmermann. “The Prehistoric and Preindustrial Deforestation of Europe”. *Quaternary Science Reviews* 28 (2009), 3016–3034.

Kaplan et al. 2010
J.O. Kaplan et al. “Holocene Carbon Emissions as a Result of Anthropogenic Land Cover Change”. *The Holocene* (2010). DOI: 10.1177/0959683610386983.

Lang and Bork 2006
A. Lang and H.-R. Bork. “Past Soil Erosion in Europe”. In *Soil Erosion in Europe*. Ed. by J. Boardman and J. Poesen. Chichester: John Wiley & Sons, 2006, 465–476.

Löhr 2000
H. Löhr. “Accelerated Roman Soil Erosion in the Mosel Valley around Trier, Germany”. In *Geoarchaeology of the Landscapes of Classical Antiquity. International Colloqium Gent, 23 – 24 October 1998*. Ed. by F. Vermeulen and M. de Dapper. Babesch Supplementa 5. Leuven: Peeters Press, 2000, 33–35.

Macklin, Jones, and Lewin 2010
M.G. Macklin, A.F. Jones, and J. Lewin. “River Response to Rapid Holocene Environmental Change: Evidence and Explanation in British Catchments”. *Quaternary Science Reviews* 29 (2010), 1555–1576.

Moldenhauer, Heinrich, and Vater 2010
K.M. Moldenhauer, J. Heinrich, and A. Vater. “Causes and History of Multiple Soil Erosion Processes in the Northern Odenwald Uplands”. *Erde* 141 (2010), 171–186.

Notebaert and Verstraeten 2010
B. Notebaert and G. Verstraeten. “Sensitivity of West and Central European River Systems to Environmental Changes during the Holocene: A Review”. *Earth-Science Reviews* 103 (2010), 163–182.

Reiß et al. 2009
S. Reiß et al. “Land Use History and Historical Soil Erosion at Albersdorf (Northern Germany) – Ceased Agricultural Land Use after the Pre-historical Period”. *Catena* 77 (2009), 107–118.

Stolz 2011
C. Stolz. "Spatiotemporal Budgeting of Soil Erosion in the Abandoned Fields Area of the "Rahnstätter Hof" near Michelbach (Taunus Mts., Western Germany)". *Erdkunde* 65 (2011), 355–370.

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