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Interrelationships between climate and human cultural development

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Human influence on the environment increased continuously during the late Holocene and often interferes with the reconstruction of climatic fluctuations in natural archives. However, for the first millennium BC there exist convincing evidences of a climatic deterioration determined by geological, geomorphological, paleoecological and archaeological records from Europe and beyond. A fluctuation in the Δ^{14}C record from tree rings indicates that this climatic setback seems to be of a global character which would support its solar origin. Geochemical and physical data of very well-dated lacustrine sediments from a German maar (Lake Holzmaar, West Eifel Volcanic Field) records a dramatic environmental change which coincides with or follows this climatic deterioration at 800 BC. These changes are related to a conspicuous shift towards an increased erosion of the soils in the catchment area. Thus sediment yields of the lacustrine system more than quadruple from the low mean mid-Holocene (7900-800 BC) level of 1.5 t km^{-2} yr^{-1} to values of 6.3 t km^{-2} yr^{-1} for the last centuries of the first millennium BC, i.e. until the start of the Roman occupation in the West Eifel region around 50 BC. Still, this elevated sediment yield value is rather low compared to 19 t km^{-2} yr^{-1} reached during the period of the Roman Empire (50 BC-400 AD) or even to 25 t km^{-2} yr^{-1} that were gained during the Middle Ages (11^{th} to 13^{th} century). During the Migration Period and the early Middle Ages, however, sediment yield data decreased again to almost mid-Holocene values of 2.3 t km^{-2} yr^{-1}.

Whether the shift in ecosystem stability following immediately after 800 BC was triggered by a solar-induced climatic change cannot absolutely be excluded but must be cast into doubt. Intensive deforestation indicated by pollen analyses suggests that human cultural development from the late Bronze Age to the early Iron Age, accompanied by the introduction of iron tools, was the reason for this alteration. Using iron tools people were much more efficient to cut down trees and till their fields. The combination of a reduced plant cover causing an increased surface runoff with the destruction of the natural topsoil by tillage operations resulted in accelerated soil erosion and thus completely changed the runoff-controlled hydrological regime of the catchment area and also the conditions in the lacustrine depositional system of Lake Holzmaar.

Presumably, the cultural change from bronze to iron manufacturing societies was not triggered by climate change around 800 BC. Such a technological shift seems to be rather slow and depends on the process of knowledge transfer temporally (from generation to generation) as well as also regionally (from tribe to tribe). However, a period of climatic deterioration which most certainly came along with a decline in agricultural productivity might have been a process to accentuate this cultural transition and to accelerate the spread of the new technology. Moreover, this process elucidates that owing to favorable circumstances human societies might be capable to cope with sudden climatic shifts. The amount of environmental damage this might cause remains an open question and can only be estimated for scenarios from the past. The non-linear behaviors of environmental systems with thresholds that can be passed make reliable predictions for the future not very resilient.