TWEEENVEERTIGSTE KROON-VOORDRACHT

CORRIE C. BAKELS

MAN: MANIPULATOR OF HIS PHYSICAL ENVIRONMENT

GERRIT HEINRICH KROON
(1868-1945)

MAN: MANIPULATOR OF HIS PHYSICAL ENVIRONMENT

TWEEENVEERTIGSTE KROON-VOORDRACHT

GEHOUDEN VOOR DE
STICHTING NEDERLANDS MUSEUM
VOOR ANTHROPOLOGIE EN PRAEHISTORIE

TE LEIDEN OP 6 NOVEMBER 2020

DOOR

PROFESSOR DR. CORRIE C. BAKELS

EMERITUS HOOGLERAAR PALEO-ECONOMIE
UNIVERSITEIT LEIDEN

INTRODUCTION

...Siccare Pomptinas paludes; emittere Fucinum lacum; viam munire a mare Supero per Apennini dorsum ad Tiberim usque; perfodere Isthmum...

This part of a Latin text can be found in the work De Vita Caesarum by the Roman author Suetonius (c. 69-after 130 AD). It describes the lives of Roman emperors and the quotation derives from the life of Julius Caesar (source The Latin library). In translation it tells us

…he intended to drain the Pontine marshes, to cut a channel for the discharge of the waters of lake Fucinus, to build a road from the Adriatic Sea passing over the Apennine mountains to the river Tiber, to make a cut through the Isthmus of Corinth…

Julius Caesar was murdered before he could execute all these plans, but his successors managed to carry out some of them. The emperor Claudius, for instance, undertook the drainage of Lake Fucinus, near l'Aquila, Italy, which frequently inundated its surroundings to the misfortune of local farmers. An impressive complex of tunnels was built to achieve the drainage. The works, dating to the 1st century AD, are still remarkable structures and can be visited in the archaeological site Parco dei Cuniculi.

The 'taming' of Lake Fucinus is an example of the manipulation of the physical environment by humans. People have trouble with water and do something about it. They alter their environment according their wishes. This is not a trait exclusive to the Romans. It is an essential part of human nature. In the following I will offer some far-reaching examples.

FIREMAKING

The first example is firemaking. Fire has many applications. It can be used for cooking, for making tools etc., but it is also a very important factor in the manipulation of the physical environment. For instance, with fire humans are able to heat the temperature of the air around them. They can control cold temperature. The use of fire is generally thought to precede the actual production of fire. Fire originating from lightning strikes or volcanic eruptions might have been caught by humans, nurtured and controlled. How far back such practices reach is open to hot debates (see for instance Roebroeks and Villa (2011)). For me such sources of fire are too chancy to count as tools to manipulate the environment in a regular way. Manipulation requires reliable control and that is provided by the skill of making fire (Figure 1).

The first humans able to produce fire at will were the Neandertals in the Middle Pleistocene c. 50,000 years ago. This is inferred from macroscopic and microscopic traces on certain tools. Microwear analysis indicates that some bifacial flint tools (bifaces) may have been used to strike a hard mineral, probably pyrite, in order to produce sparks (Sorensen *et al.* 2018).

Fire can be used also in other ways to manipulate the environment. Hunter-gatherers alter their environment by burning to improve the predictability and yield of animal as well as plant resources. In 'burning the land' Scherjon *et al.* (2015) suggest that such off-site use might be as old as regular fire use. It is even speculated upon that it might be as old as Neandertal presence in Last Interglacial environments. The view that Neandertals were just part of the landscape 'furniture' is contested by Roebroeks and Bakels (2015). They argue that these hominins had technologies in the form of hunting tools and fire, and the knowledge to

Figure 1. Humans and fire. Painting by José Maria Velasco, Museo Nacional de Arte, Mexico.

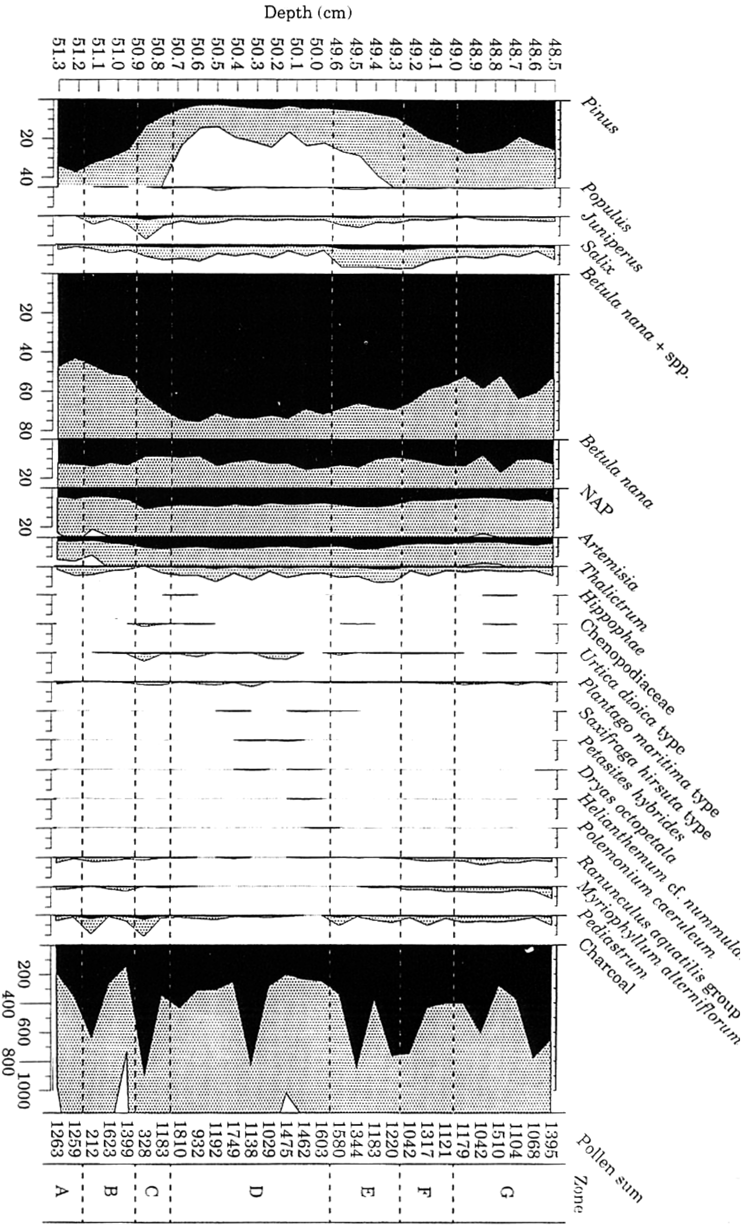
use them, although the deliberate use of fire to alter the landscape is not visible in palaeo-environmental records.

OPENING-UP LANDSCAPES

Opening-up landscapes is a practice that is part of human behaviour. Where no natural open space is available to dwell in, people will create it. The man-made space needs not be to be large, and the oldest occurrences may go undetected. An example of an early small-scale deforestation was described by Bos and Janssen (1996). They estimated the extent of human activity by means of a series of pollen diagrams along a transect in a former Lateglacial lake at Milheeze, southern Netherlands. Excavations had revealed Late Palaeolithic Federmesser camps (10,500 BP) along its margin. The transect followed a line from the centre of the lake towards the shore. Pollen analysis showed a repetition of small-scale, very local changes of the vegetation, which were contemporaneous with human occupation. Pine trees, the dominant tree in that period at that location, gave way to an herb vegetation. The changes are attributed to a small-scale human impact (Figure 2).

Creating open space was certainly not restricted to Milheeze, but must have been a common activity. If it is assumed that the number of humans grew during the Holocene, open space must have become larger. Permanent occupation of sites made rapid

Figure 2. Pollen diagram from a lake at Milheeze, the Netherlands. Pollen curves show % values (black) plus 5x exaggeration (grey). The decline in pine (Pinus) pollen starts in vegetational zone B and ends during zone F. The decline and minimum are contemporaneous with a Late Palaeolithic occupation of the lake's shore. Source: Bos and Janssen (1996).


Depth (cm)
51.3
51.2
51.1
51.0
50.9
50.8
50.7
50.6
50.5
50.4
50.3
50.2
50.1
50.0
49.6
49.5
49.4
49.3
49.2
49.1
49.0
48.9
48.8
48.7
48.6
48.5
Pinus
Populus
Juniperus
Salix
Betula nana + spp.
Betula nana
NAP
Artemisia
Thalictrum
Hippophae
Chenopodiaceae
Urtica dioica type
Plantago maritima type
Saxifraga hirsuta type
Petasites hybrides
Dryas octopetala
Polemonium caeruleum
Ranunculus aquatilis group
Myriophyllum alterniflorum
Pediastrum
Charcoal
Pollen sum
1263
1259
212
1623
1399
328
1183
1810
932
1192
1749
1138
1029
1475
1462
1603
1580
1344
1183
1220
1042
1317
1121
1179
1042
1510
1104
1068
1395
Zone
A
B
C
D
E
F
G

recovery of the original vegetation difficult, if not impossible. The combination of opening-up for hunting-gathering through burning and opening-up for dwelling must have given the first push towards the disappearance of forests in landscapes where trees are supposed to dominate the climax vegetation. Later, the shift from hunting-gathering to farming resulted in an open landscape.

Roberts *et al.* (2017) provided an overview of the deforestation of Europe. They conclude that serious forest loss has been a dominant feature since 6000 years ago, resulting in a mosaic of forest and non-forest. Today forest covers less than half of Europe's surface, northern Europe included (Roberts *et al.* 2017).

Deforestation by humans is not restricted to Europe. It is a worldwide phenomenon. Many studies have reported on this kind of manipulation of the environment and its results. A compilation of 632 records globally by Jenny *et al.* (2019), for instance, has amply shown this.

ANIMAL HUSBANDRY AND PLANT CULTIVATION

As mentioned before, hunter-gatherers may have manipulated their environment through burning in order to facilitate hunting. Forest clearance may have promoted the growth of desirable plants. One of these plants is hazel. Although this shrub tolerates some shade, it thrives best when tall trees are absent, for instance at forest edges. In north-western and Central Europe hazel preceded the taller deciduous trees when the forest returned after the Last Ice Age. This is neither the case in the southern Alpine area nor in previous interglacials (Finsinger *et al.* 2006). Huntley (1993) wrote that a unique combination of climatic conditions during the early Holocene, perhaps along with a high fire frequency that resulted from these conditions, favoured the rapid spread and dominance of hazel for several millennia in north and Central Europe. Warm summers and frequent summer water deficits, combined with still cold winters would have delayed the expansion of tall deciduous trees (Huntley 1993).

The dominance of hazel was contemporaneous with the Early Mesolithic hunter-gatherers. It might fairly have been that the natural fires suggested by Huntley, were supplemented by human action. Hazelnuts are very common finds in Mesolithic sites (see for instance Holt 2010).The nuts were much appreciated, because they have high value as food and keep well in storage, and several authors suspect the Mesolithic population of north-western Europe of active promotion of the growth of hazel in order to obtain extra quantities of hazelnuts for winter-store (Smith 1970; Zvelebil 1994; Bos and Urz 2003) (Figure 3).

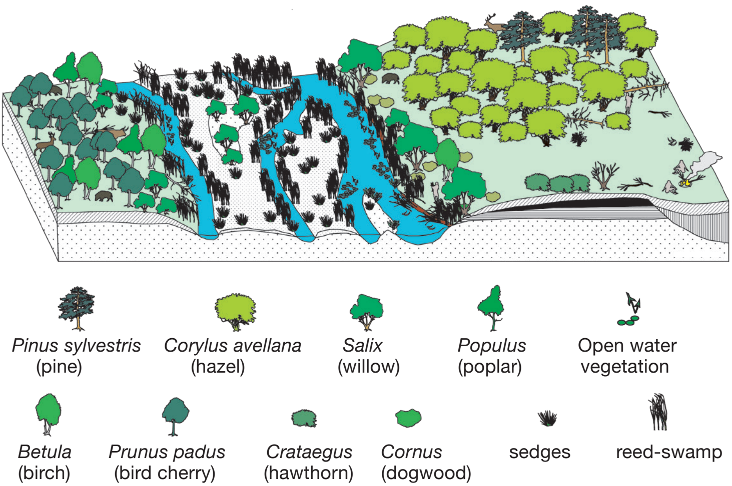


Figure 3. Reconstruction of the Mesolithic landscape of the middle Lahn valley, Germany, showing the dominance of hazel near the campsite depicted at bottom right. Source: Bos and Urz (2003).

This kind of manipulation of the environment culminated in the development of animal husbandry and plant cultivation. The wish to have the main sources of food at hand and on a more or less predictable scale must have triggered the advent of agriculture. The shift to an active production of food took place almost everywhere in the world, although not at the same time. In the Near East animal domestication started some 11,000-10,000 years ago (Vigne 2011). The first crops appeared at the same time (Willcox 2007; Weiss and Zohary 2011). China domesticated pigs from 6000 BC onwards (Vigne 2011) and knew at least two centres of plant domestication, one based on rice with a start around 7000 BC or even earlier (Molina 2011) and one based on millet, starting around 8000 BC (Lu *et al.* 2009). A few thousand years later agriculture was practiced in South America, Mesoamerica and New Guinea (Stahl and Norton 1987; Piperno 2009; Denham *et al.* 2003). In all these parts of the world this step in the manipulation of the environment was taken independently.

MANIPULATION OF SOILS

The production of food led to another kind of manipulation i.e. improvement of the growing conditions for crops. Manuring and water management were the next step. Today the application of stable-isotope analysis to the remnants of crops provides the check that such practices were indeed carried out, without the need for establishing this by proxies such as phosphate analysis of ancient soils or the mapping of irrigation canals.

The ratio of the nitrogen isotopes ^{15}N and ^{14}N indicates manuring and the ratio of the carbon isotopes ^{13}C and ^{12}C measures water conditions. The analysis can be applied even to charred seeds. In this way it could be established that Bronze Age farmers (1500 BC) in the north-western Netherlands manured their soils (Bakels

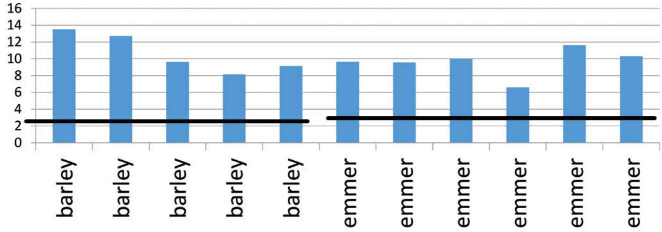


Figure 4. The ratio of N values, δ15N values (Y-axis), of charred barley and emmer wheat from Bronze Age sites in the north-western Netherlands. The black bars indicate the base-line, i.e. the values belonging to the cereals grown without manure. The Bronze Age values exceed the base-lines to a considerable extent, proof of substantial manuring.

2018) (Figure 4). In Denmark Kanstrup *et al.* (2014) found that the positive effect of manuring was recognized through the whole period of early agriculture, and that substantial and systematic manuring occurred in the Early Iron Age (500 BC).Stable isotope analysis showed that during the late Uruk to Early Dynastic III period (3500-2350 BC) irrigation was practiced at Abu Salabileh (Iraq) (Wallace *et al.* 2015).

Nevertheless, the proxies provide very valuable information, especially in the case of water management. Abu Salabileh is situated along an irrigation canal branching off the river Euphrates. In this region, Mesopotamia, ancient river channels are well mapped and are seen to have been intentionally modified into canals (Jacobsen and Adams 1958; Gibson 1974). The oldest system dates to 3000-2400 BC (Jacobsen and Adams 1958).

Canal irrigation was, and is, practiced also in other parts of the world, for instance in the Indus region, China, Mesoamerica and Peru (Spooner 1974; Schjellerup 2016). Irrigation on the north coast of Peru started perhaps as early as 4000-3000 BC, although on a very small scale. More substantial irrigation is reported from the 1st millennium BC, whilst the major works in Peru seem to belong to the 1st millennium AD and later (Denevan 2001, 143). Such systems have a considerable impact on the landscape and can truly be classed as a major manipulation of the physical environment. In the region traversed by the river Diyala, a tributary of the river Tigris, Mesopotamia, all settlements in a 9000 km^2 area were dependent on irrigation as early as 1800-1700 BC (Jacobsen and Adams 1958) (Figure 5). Engel (1976) writes that in the Cañete valley on the Peruvian coast the initial 1500 ha of arable land expanded through irrigation into 15,000 ha.

Another way to bring water to arable land too dry for growing plants is the *qanat*. Subterranean tunnel-wells (qanats) are gently sloping tunnels connecting a place with a reliable groundwater level with a place where a reliable presence of water is required. Water flows in a natural way down the slope with minimal loss. The tunnels have to be dug; to give the diggers access to air and a means to remove the spoil vertical shafts are constructed every 50 to 150 m along their course (English 1968). The tops of the shafts are surrounded by the excavated earth and display well visible lines across the landscape. The tunnels can be very long. Those at Kirman (Iran) extend over 50 km (Figure 6 and 7).

The qanat is considered to have been invented in pre-Achaemenid Persia, that is before 600 BC. From there the technology spread to Central Asia, western China, North Africa, Spain, the Canary Islands and even to Europe north of the Alps. For instance, qanats delivered water to the Roman town Trier, Germany, and farms in its neighbourhood (Kremer 1999). Mesoamerica and South

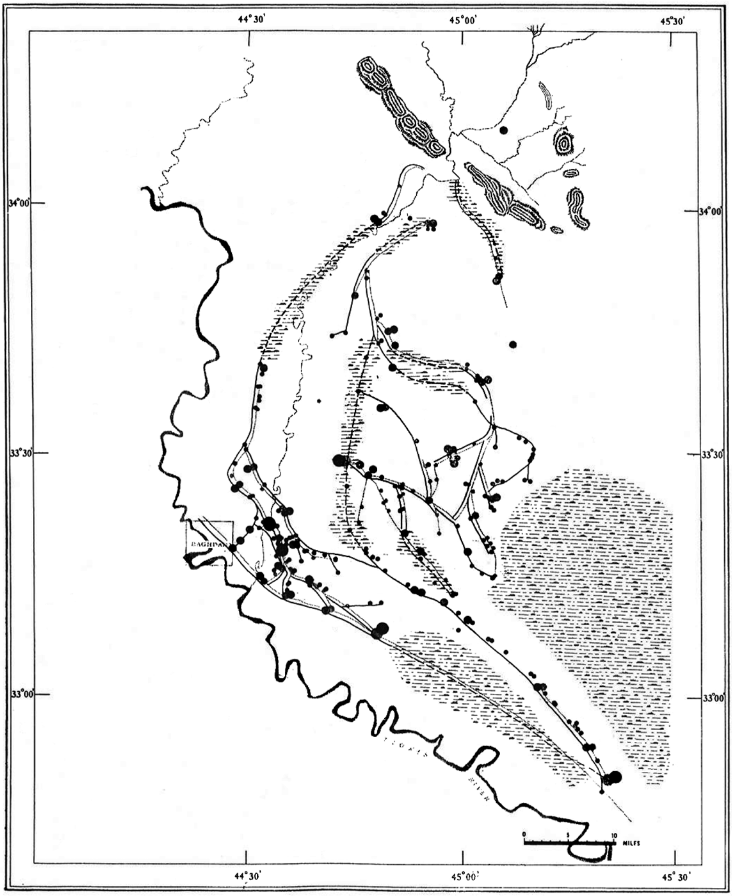
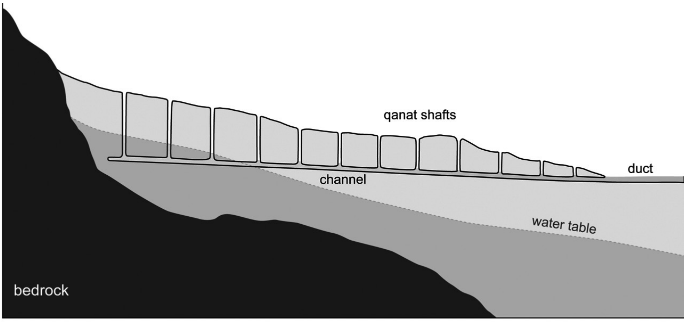


Figure 5. Early canalized watercourses and settlements (dots) in the Diyala region. Double lines indicate the oldest system. The meandering river is the river Tigris. The bar at bottom right represents 10 miles. Source: Jacobsen and Adams (1958).



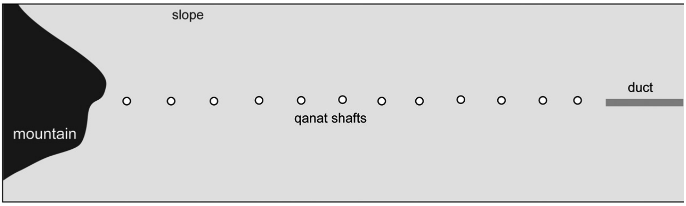


Figure 6. Qanat in section and from above. Adapted from English (1968).

Figure 7. Qanat at Erg Chebbi, Morocco. Photo W.J. Kuijper.

America have qanats as well. The system was introduced by the Spaniards, but something like a qanat may date already as far back as pre-Columbian times (English 1968).

ENLARGING SURFACES

Improving soil and land is one thing, enlarging the usable surface is another. Slopes are prone to provide difficulties. The way to handle them is terracing. Converting slopes into a series of level, horizontal strips was and is practiced world-wide (Arnáez *et al.* 2015 and the references therein). A common method is to build stone walls that act as risers to support the treads of level soil (Figure 8).

Figure 8. Terraces on a slope in Yemen. Photo C.C. Bakels.

Dating terraces is notoriously difficult as the walls have to be maintained, repaired and rebuilt over and again. Remnants of material culture such as ceramics are of limited use, because they are often displaced and the same is true for charcoal. At present, OSL dating of accumulated earth is considered to offer more reliable results (Avni *et al*. 2013). With this method Avni *et al*. found that systems in the Negev highlands dated to the 4th-11th centuries AD, younger than the previously assumed 1st-7th centuries AD. Notwithstanding this warning, it may be said that terracing is an old practice. In the Near East and the Mediterranean terracing slopes dates back to the 2nd millennium BC (Asins-Veles 2006). According to Brooks (in Denevan 2001), terrace construction in the Andes (Colca valley) dates back to 2480-2320 BC. Other systems in South America were established by at least 900-200 BC, but the main and most impressive pre-Columbian terraces were built by the Incas in the 13th-15th centuries AD (Goodman-Elgar 2008; Schjellerup 2016).

A different way to enlarge surface is land reclamation. Converting marshes, lakes and parts of the sea into habitable land is a practice of which the (pre)history is hardly studied. According to Suetonius, cited above, Julius Caesar wanted to drain the Pontine marshes, and Roman emperors after him tried to achieve this. The capital of the Aztecs, Tenochtitlán, the predecessor of the city of Mexico, was initially founded on two islands in a lake, Lake Texcoco, but when the inhabitants sought to enlarge the city, they created artificial islands for residential space and garden plots (Calnek 1972). This was done in the first half of the 14th century AD. Artificial islands, known as chinampas, are still in use around Mexico City as horticultural land. They comprise 2000 ha and are recognized by the FAO as an Agricultural Heritage System (source FAO regional office for Latin America and the Caribbean) (Figure 9).

Figure 9. Chinampas. Source Wikipedia.

The Dutch started to reclaim parts of the sea in the Middle Ages (see for instance Hacquebord and Hempenius 1990) (Figure 10). Today complete new stretches of land are created in several parts of the world.

PROBLEMS

My aim in offering the examples presented above is to demonstrate that the manipulation of the physical environment by humans is nothing new. People have always tried to make the environment better for themselves in their own eyes. Obviously, this is part of human nature. The manipulations resulted in visible alterations of the earth's terrestrial surface and atmosphere. The ends were gained: people need not huddle in the cold anymore,

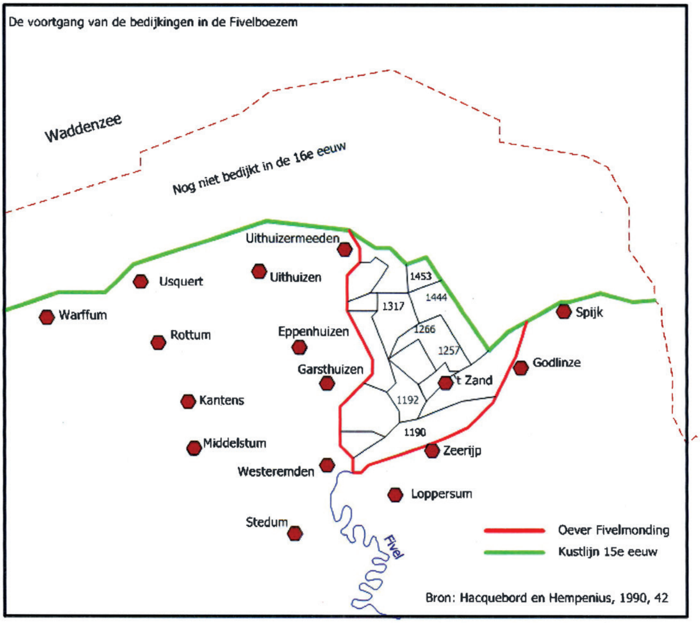


Figure 10. Medieval land reclamation in the mouth of the river Fivel, northwest Groningen, the Netherlands. Red line, the original shore; green line, the 15th century coast-line; broken line, present coast-line. The ciphers indicate the year of reclamation. Source Hacquebord and Hempenius (1990).

live in light and open space, and control their food supply. That is, in general.

Manipulation can run out of control. I will not present a list of problems, but there are two problems I wish to dwell upon, because they are long-standing and have to be mentioned in a lecture intended for archaeologists.

The first is soil salinity. Shadid *et al.* (2018) wrote “soil salinity is a major global issue owing to its adverse impact on agricultural productivity and sustainability… The association between humans and salinity has existed for centuries and historical records show that many civilizations have encountered problems due to increases in the salinity of agricultural fields”. Much of the salinization is the result of irrigation. A well-known example is Ancient Mesopotamia (Jacobsen and Adams 1958), where as early as 2400 BC problems were felt related to salt-induced land degradation. Irrigation water always contains soluble salts. An accumulation of these salts in soil occurs in cases of imbalance between evaporation and precipitation, and salts are not leached but remain in the upper soil layers. Unless the salts are washed down they impede the growth of plants. Uncontrolled irrigation in combination with inadequate drainage ends in salinization. In Mesopotamia increasing salinity led to a shift from the cultivation of wheat to the more salt-tolerant barley, and a decline in agricultural yields (Jacobsen and Adams 1958).

Another instance is the occupation history of the lower Virú Valley in Peru. There irrigation began between 800 BC and 30 AD, but from 1200 AD onwards the population of the valley declined considerably and people resettled more upstream (Willey 1953). The decline is partly ascribed to salinization of their fields. According to Shadid *et al.* (2018), today some ten million ha of irrigated land has had to be abandoned annually because of salinization and related problems.

The second major problem is soil erosion. Van Andel *et al.* (1990) wrote "soil erosion resulting from human exploitation of the land has attracted much public and scientific interest. Being regarded mainly as a modern phenomenon, however, its prehistoric and historical extent remain largely unexplored". These authors focused on Greece and concluded that most recorded Holocene erosion events are related to human interference in the landscape. A major phase of erosion took already place in the Late Neolithic to Early Bronze Age, that is mid-4th to mid-3rd millennium BC (Van Andel *et al.* 1990).

Other reports come from China. He *et al.* (2004) studied the north-western loess plateau, which originally was a high, flat plain. At present it is a gully-hill landscape due to mass soil erosion. Deep gullies occupy 30-50% of the landscape. The cause is natural erosion and human induced erosion, but the latter was four times as intense as the former, and started 3000 years ago (He *et al.* 2004).

Jenny *et al.* (2019) wrote "accelerated soil erosion has become a pervasive feature on landscapes around the world and is recognized to have substantial implications for land productivity, downstream water quality, and biochemical cycles. However, the scarcity of global syntheses that consider long-term processes has limited our understanding of the timing, the amplitude, and the extent of soil erosion over millennial scales". They concluded on the basis of a study of lake sedimentation rates world-wide, that a significant portion of the Earth's surface was subjected to human-driven erosion already 4000 years ago.

CONCLUSION

In focusing on large-scale manipulations of the physical environment I have tried to demonstrate the impulse felt by humans to do something about the world they live in. The existence of such an impulse can be traced back as far as 50,000 years ago. Modifying environments is not a trait exclusive to humans. Many animals do something about their environment as well. Jones *et al*. (1994) provide a substantial list of animals and even plants. A clear example is dam-building by beavers (Figure 11). But humans have gone to greater lengths and all 'improvements' are still valued today. Fire, open space, agriculture and the ability to enlarge usable surface are assets of present life. All require technical abilities with increasing complexity when placed in a chronological order. The last mentioned, enlarging the surface, is the youngest and the most complicated when applied on any substantial scale.

Figure 11. Dam built by a solitary beaver in the rivulet De Roode Beek near Sittard, the Netherlands.
Photo W. de Koning http://europesebever.blogspot.com/.

ACKNOWLEDGEMENTS

First of all, I would like to thank the Board of the Stichting Nederlands Museum voor Anthropologie en Praehistorie for the invitation to deliver the 42nd Kroon-Voordracht. It gave me the opportunity to express some thoughts on a subject which was already for some time on my mind. Hanneke Bos and Ralf Urz provided me with a colour version of their beautiful reconstruction of a Mesolithic landscape. Wim Kuijper allowed me to use his photo of a qanat. Willy de Koning drew my attention to her website when I was looking for a picture of the work of a Dutch beaver. And last but not least, Sasja van der Vaart-Verschoof was so kind as to ameliorate my English. My thanks go to all of them.

REFERENCES

Arnáez J., N. Lana-Renault, T. Lasanta, P. Ruiz-Flaño and J. Castroviejo (2015). Effects of farming terraces on hydrological and geomorphological processes, a review. *Catena* 128, 122-134.

Asins-Veles S. (2006). Linking historical terrace with water catchment, harvesting and distribution structures. In: *The archaeology of crop fields and gardens*, J.-P. Morel, J. Tresseras Juan and J.C. Matamala (eds). Bari, Edipuglia, 21-40.

Avni, G, N. Porat and Y. Avni (2013). Byzantine-Early Islamic agricultural systems in the Negev highlands: stages of development as interpreted through OSL dating. *Journal of Field Archaeology* 38(4), 332-346.

Bakels, C. (2018). Maintaining fertility of Bronze Age arable land in the northwest Netherlands. *Analecta Praehistorica Leidensia* 49, 65-76.

Bos, J.A.A. and C.R. Janssen (1996). Local impact of Palaeolithic man on the environment during the end of the Last Glacial in the Netherlands. *Journal of Archaeological Science* 23, 731-739.

Bos, J.A.A. and R. Urz (2003). Late Glacial and early Holocene environment in the middle Lahn valley (Hessen, central-west Germany) and the local impact of early Mesolithic people – pollen and macrofossil evidence. *Vegetation History and Archaeobotany* 12, 19-36.

Calnek E.E. (1972). Settlement pattern and chinampa agriculture at Tenochtitlán. *American Antiquity* 37, 104-115.

Denevan, W.M. (2001). *Cultivated landscapes of native Amazonia and the Andes*. Oxford, Oxford Geographical and Environmental Studies.

Denham, T.P., S.G. Haberle, C. Lentfer, R. Fullagar, J. Field, M. Therin, N. Porch and B. Winsborough (2003). Origins of Agriculture at Kuk Swamp in the Highlands of New Guinea. *Science* 301 (5630), 189-193.

English, P.W. (1968). The origin and spread of qanats in the old world. *Proceedings of the American Philosophical Society* 112(3), 170-181.

Finsinger, W., W. Tinner, W.O. van der Knaap and B. Ammann (2006). The expansion of hazel (*Corylus avellana* L.) in the southern Alps: a key for understanding its early Holocene history in Europe? *Quaternary Science Reviews* 25, 612-631.

Gibson, M. (1974). Violation of fallow and engineered disaster in Mesopotamian civilization. In: *Irrigation's impact*, T.E. Downing and M. Gibson (eds).Tucson, Arizona, The University of Arizona Press, 7-19.

Goodman-Elgar M. (2008). Evaluating soil resilience in long-term cultivation: a study of pre-columbian terraces from the Paca valley, Peru. *Journal of Archaeological Science* 35, 3072-3085.

Hacquebord L. and A.L. Hempenius (1990). *Groninger dijken op deltahoogte*. Groningen, Wolters-Noordhoff / Egbert Forsten.

He, X., K. Tang and X. Zhang (2004). Soil erosion dynamics on the Chinese loess plateau in the last 10,000 years. *Mountain research and development* 24 (4), 342-347.

Holst, D. (2010). Hazelnut economy of early Holocene hunter-gatherers: a case study from Mesolithic Duvensee, northern Germany. *Journal of Archaeological Science* 37, 2871-2880.

Huntley, B. (1993). Rapid early Holocene migration and high abundance of hazel (*Corylus avellana* L.): alternative hypotheses. In: *Climate change and human impact on the landscape*, F.M. Chambers (ed.). London, Chapman and Hall, 205-215.

Jacobsen, T and R.M. Adams (1958). Salt and silt in ancient Mesopotamian agriculture. *Science* 128 (3334), 1251-1258.

Jenny, J.-P., S. Koirala, I. Gregory-Eaves, P. Francus, C. Niemann, B. Ahrens, V. Brovkin, A. Baud, A.E.K. Ojala, A. Normandeau, B. Zolitschka and N. Carvalhais (2019). Human and climate global-scale imprint on sediment transfer during the Holocene. *PNAS* 116 (46), 22972-22976.

Jones, C.G., J.H. Lawton and M. Shachak (1994). Organisms as ecosystem engineers. *Oikos* 69, 373-386.

Kanstrup, M., M.K. Holst, P.M. Jensen, I.K. Thomsen and B.T. Christensen (2014). Searching for long-term trends in prehistoric manuring practice; $\delta^{15}N$ analyses of charred cereal grains from the 4th to the 1st millennium BC. *Journal of Archaeological Science* 51, 115-125.

Kremer, B. (1999). Wasserversorgung aus dem Tunnel, der römische Qanat von Mehring. *Funde und Ausgrabungen im Bezirk Trier* 31, 37-50.

Lu, H., J. Zhang, K-b Liu, N. Wu, Y. Li, K. Zhou, M. Ye, T. Zhang, H. Zhang, X. Yang, L. Shen, D. Xu and Q. Li (2009). Earliest domestication of common millet (*Panicum miliaceum*) in East Asia extended to 10,000 years ago. *PNAS* 106 (18), 7367-7372.

Molina, J., M. Sikora, N. Garud, J.M. Flowers, S. Rubinstein, A. Reynolds, P. Huang, S. Jackson, B.A. Schaaf, C.D. Bustamante, A.R. Boyko and M. D. Purugganan (2011). Molecular evidence for a single evolutionary origin of domesticated rice. *PNAS* 108 (20), 8351-8356.

Piperno, D.R., A.J. Ranere, I. Holst, J. Iriarte and R. Dickau (2009). Starch grain and phytolith evidence for early ninth millennium B.P. from the Central Balsas river valley, Mexico. *PNAS* 106 (13), 5019-5024.

Roberts, N., R.M. Fyfe, J. Woodbridge, M.-J. Gaillard, B.A.S. Davis, J.O. Kaplan, L. Marquer, F. Mazier, A.B. Nielsen, S. Sugita, A.-K Trondman and M. Leydet (2018). Europe's lost forests: a pollen-based synthesis for the last 11,000 years. *Nature, Scientific Reports* 8, 716.

Roebroeks, R. and P. Villa (2011). On the earliest evidence for habitual use of fire in Europe. *PNAS* 108 (13), 5209-5214.

Roebroeks, W. and C. Bakels (2015). 'Forest Furniture' or 'Forest Managers'? On Neanderthal presence in last interglacial environments. In: *Settlement, Society and Cognition in Human Evolution, landscapes in mind,* F. Coward, R. Hosfield, M. Pope and F.Wenban-Smith (eds). Cambridge, Cambridge University Press,174-188.

Scherjon, F., C. Bakels, K. MacDonald and W. Roebroeks (2015). Burning the land. *Current Anthropology* 56(3), 299-326.

Schjellerup, I. (2016). Landscape change and agricultural terraces in the Peruvian Andes. In: *Earth 3, Agricultural and pastoral landscapes in pre-industrial society*, F. Retamero, I. Schjellerup and A Davies (eds). Oxford, Oxbow Books, 187-200.

Shahid, S.A., M. Zaman and L. Heng (2018). Soil salinity: historical perspectives and a world overview of the problem. In: *Guideline for salinity assessment, mitigation and adaptation using nuclear and related techniques*, M. Zaman, S. Shahid and L. Heng (eds). Springer, 43-53.

Smith, A.G. (1970). The influence of Mesolithic and Neolithic man on British vegetation: a discussion. In: *Studies in the vegetational history of the British Isles*, D. Walker and R.G. West (eds). Cambridge, Cambridge University Press, 81-96.

Sorensen, A.C., E. Claud and M. Soressi (2018). Neandertal fire-making technology inferred from microwear analysis. *Nature, Scientific Reports* 8,10065.

Spooner, D.M., K. McLean, G. Ramsay, R. Waugh and G.J. Bryan (2005). A single domestication for potato based on multi locus amplified fragment length polymorphism genotyping. *PNAS* 102 (41), 14694-14699.

Stahl, P.W. and P. Norton (1987). Precolumbian animal domesticates from Salango, Ecuador. *American Antiquity* 52(2), 382-391.

Van Andel, T.H., E. Zangger and A. Demitrack (1990). Land use and soil erosion in prehistoric and historical Greece. *Journal of Field Archaeology* 17, 379-396.

Vigne, J.-D. (2011). The origins of animal domestication and husbandry: a major change in the history of humanity and the biosphere. *Comptes Rendus Biologies* 334, 171-181.

Wallace, M.P., G. Jones, M. Charles, R. Fraser, T.H.E. Heaton and A. Bogaard (2015). Stable carbon isotope evidence for Neolithic and Bronze Age crop water management in the eastern Mediterranean and Southwest Asia. *Plos One* 10(6), e0127085.

Weiss, E. and D. Zohary (2011). The Neolithic southwest Asian founder crops, their biology and archaeobotany. *Current Anthropology* 52, Supp. 4, 137-254.

Willcox, G. (2007). The adoption of farming and the beginnings of the Neolithic in the Euphrates valley: cereal exploitation between the 12th and 8th millennia cal BC. In: *The origins and spread of domestic plants in southwest Asia and Europe*, S. Colledge and J. Connolly (eds). Walnut Creek CA, University College of London Institute of Archaeology Publications, 21-36.

Willey, G.R. (1953). Prehistoric settlement patterns in the Virú valley, Peru. *Bureau of American Etnology Bulletin* 155, Smithsonian Institute.

Zvelebil, M. (1994). Plant use in the Mesolithic and its role in the transition to farming. *Proceedings of the Prehistoric Society* 60, 35-74.

eerste kroon-voordracht (1971)
G. Bosinski, *Die Tierdarstellungen des Magdalénien Fundplatzes Gönnersdorf bei Neuwied*

tweede kroon-voordracht (1975)
F. Anders, *Kunst und Kunstgewerbe Altmexikos*

derde kroon-voordracht (1977)
C.B.M. McBurney, *Archaeology and the Homo Sapiens Sapiens Problem in Northern Africa*

vierde kroon-voordracht (1978)
Raymond H. Thompson, *Mesoamerica and the Goals of Archaeology*

vijfde kroon-voordracht (1981)
J.K.S. St Joseph, *Air Photography and Archaeology: Achievements and Prospects*

zesde kroon-voordracht (1983)
Glynn Isaac, *Early Stages in the Evolution of Human Behavior: the Adaptive Significance of Stone Tools*

zevende kroon-voordracht (1984)
H.T. Waterbolk, *Archeologie en Landschap*

achtste kroon-voordracht (1985)
Tim D. White, *Acheulian Man in Ethiopia's Middle Awash Valley: The Implications of Cutmarks on the Bodo Cranium*

negende kroon-voordracht (1986)
M. Biddle, *The Thames and the Rhine: urban origins in the Channel-region (paper presented for the Ninth Kroon-Voordracht (1986); manuscript for publication never received)*

TIENDE KROON-VOORDRACHT (1987)
J.D. van der Waals, *De kolonisatie van het terpengebied – een ethno-archeologische benadering*

ELFDE KROON-VOORDRACHT (1988)
Jane E. Buikstra, *The mound-builders of eastern North America – a regional perspective*

TWAALFDE KROON-VOORDRACHT (1990)
David R. Harris, Settling down and breaking ground: *Rethinking the Neolithic Revolution*

DERTIENDE KROON-VOORDRACHT (1991)
W.A. van Es, *Van Maastricht naar Rhenen, een wandeling in de Laat-Romeinse tijd*

VEERTIENDE KROON-VOORDRACHT (1992)
J.D. Lewis-Williams, *Vision, Power and Dance: The Genesis of a Southern African Rock Art Panel*

VIJFTIENDE KROON-VOORDRACHT (1993)
B.W. Cunliffe*, Fertility, Propitiation and the Gods in the British Iron Age*

ZESTIENDE KROON-VOORDRACHT (1994)
J.T. Urtāns*, Latvian Hillforts: the Originality of the Archaeological Reality*

ZEVENTIENDE KROON-VOORDRACHT (1995)
Ph.V. Tobias, *The communication of the dead: earliest vestiges of the origin of articulate language*

ACHTTIENDE KROON-VOORDRACHT (1996)
O. Crumlin-Pedersen*, Archaeology and the sea*

negentiende kroon-voordracht (1997)
George Eogan, *The discovery programme: Initiation, consolidation and development*

twintigste kroon-voordracht (1998)
Leendert P. Louwe Kooijmans, *Between Geleen and Banpo, the Agricultural Transformation of Prehistoric Society, 9000 – 4000 BC*

eenentwintigste kroon-voordracht (1999)
Colin Renfrew, *Loot, Legitimacy and ownership: The ethical crisis in archaeology*

tweeëntwintigste kroon-voordracht (2000)
Erika Hagelberg, *Genetics in the study of human history: problems and opportunities*

drieëntwintigste kroon-voordracht (2001)
João Zilhão, *Anatomically archaic, behaviorally modern: The last Neanderthals and their destiny*

vierentwintigste kroon-voordracht (2002)
S. von Schnurbein, *Augustus in Germanien, neue archäologische Forschungen*

vijfentwintigste kroon-voordracht (2003)
S.W. Hillson, D.R. Brothwell and G.J.R. Maat, *Wealth, health and human Remains in archaeology*

zesentwintigste kroon-voordracht (2004)
Miranda Aldhouse-Green, *Beyond the gods: biographies, values and cosmologies in 'celtic' iconography*

zevenentwintigste kroon-voordracht (2005)
Maarten J. Raven, *Architectural principles in theory and practice: The New Kingdom Necropolis at Saqqara (Egypt)*

achtentwintigste kroon-voordracht (2006)
Paul Halstead, *What's ours is mine? Village and household in early farming society in Greece*

negenentwintigste kroon-voordracht (2007)
Peter de Knijff, *Archaeology by means of DNA: hype or here to stay?*

dertigste kroon-voordracht (2008)
Hermann Parzinger e.a., *Der Skythenzeitliche Krieger aus dem Eis: neue Entdeckungen im Mongolischen Altaj*

eenendertigste kroon-voordracht (2009)
Bernard Wood, *The Human Fossil Record: Challenges and Opportunities*

tweeëndertigste kroon-voordracht (2010)
Wil Roebroeks, *The Neandertal Experiment*

drieëndertigste kroon-voordracht (2011)
Johannes Müller, *Megaliths and Funnel Beakers: societies in change 4100-2700 BC*

vierendertigste kroon-voordracht (2012)
Albert Zink, *From Tutankhamun to Ötzi: the use of modern scientific methods in mummy research*

vijfendertigste kroon-voordracht (2013)
J. Francis Thackeray, *Human evolution from an African perspective: with reference to Charles Darwin palaeoclimate and the problem of defining a species*

zesendertigste kroon-voordracht (2014)
André F.L. van Holk, Jerzy H.G. Gawronsky, Jonathan R. Adams and Henk Dessens, *Maritime Archaeology*

ZEVENENDERTIGSTE KROON-VOORDRACHT (2015)
Lee R. Berger, *Five years after Australopithecus Sediba. New discoveries changing our understanding of human evolution*

ACHTENDERTIGSTE KROON-VOORDRACHT (2016)
Fred Spoor, *Evolving primates: a palaeontologist's view of his tribe*

NEGENENDERTIGSTE KROON-VOORDRACHT (2017)
Graeme Barker, *A tale of three caves: why was our species so successful at colonising new environments*

VEERTIGSTE KROON-VOORDRACHT (2018)
Michael Parker Pearson, *Science and Stonehenge: recent investigations of the world's most famous stone circle*

EENENVEERTIGSTE KROON-VOORDRACHT (2019)
Jean-Jacques Hublin, *The rise and spread of homo sapiens*

KROON-VOORDRACHTEN

REDACTIE: WILLY H. METZ

Printed by

DRUKKERIJ J. BOUT & ZN., HUIZEN

ISBN/EAN 978-90-829481-2-7