The grand narrative of climate change, disease and human society
Zooming in on the decline of the Roman world

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"We historians are extremely uncomfortable with the idea that natural forces in some way circumscribe human agency. Fearful of being labeled 'environmental determinists', we opt for a model of change in which all of the significant causal agents in historical processes are internal – or endogenous – to human culture, society, and economy."
John L. Brooke[1]

Introduction

In 1984, the German ancient historian Alexander Demandt listed over two hundred causes of the decline of the Roman world that had been proposed in previous scholarship. The list offers a clear illustration of the fact that our views of the past are very much determined by contemporary concerns. Famously, Edward Gibbon, child of the enlightenment, blamed the weakening of the Roman Empire on its christianization. A century ago, racial degeneration was widely accepted as a fundamental cause of the fall of Rome, while in recent years the failure to prevent the massive influx of foreigners who did not share Roman values has gained prominence in non-academic circles. Population pressure, epidemics and climate were already among the causes listed in 1984, but seem to have gained in importance in recent decades, which is no surprise in view of the present-day debates on Global Warming and overpopulation.

This paper is headed by a quote from John Brooke that highlights the contrast between endogenous and exogenous factors, between human agency and the environment. Booke ascribes an inherent, even intuitive tendency to historians to favor human agency over natural forces in the process of change in human societies. Are "we historians" indeed handicapped by this blind spot in our perception? Are we genetically disinclined to accept the subjection of human history to exogenous natural forces? Is it not possible that, if some historians remain skeptical regarding recent grand narratives that favor natural forces over all others in determining the course of societal change, they are unconvinced because they think that human societies were too complex to be determined by one or even a few causes? Causes, moreover, that are outside human control. Easy answers are not possible, if only because the complexity, adaptability and resilience of societies changed fundamentally over time. The role of natural forces in the history of mankind changed as societies became less and less the passive subjects of their environment. Totally dependent on their natural environment and with few means to control it, paleolithic hunter-gatherers were helpless in the face of changes in climate and landscape. Stone-age communities did not have the political, economic and social mechanisms to deal with adverse circumstances that more complex societies developed in the more recent past. Early-modern Britain did not come out badly from the Little Ice Age, as population

[1] John L. Brooke, *Climate change and the course of global history* (2014), pp. 1-2.

meanwhile grew, living standards rose and mortality fell. Admittedly, even modern societies have not escaped the impact of forces outside human society, but if increasing drought in eastern Africa causes bad harvests, hunger and disease, it is questionable whether the mortality crisis is to be blamed on natural forces or on the failure of the coping mechanisms in the modern world. In short, rather than a dichotomy between natural forces and human agency, it seems more appropriate to speak of a shifting balance in the role of natural and societal forces between the paleolithic and the present on the basis of socio-economic development and technological change. However, while this realization adds a few grey tones to the debate, it offers in itself little clarity about the balance and interconnectedness of natural forces and human agency over much of the past millennia. I will try to make a contribution to this debate by zooming in on the decline of the Roman world, which surely is an instructive case in view of the claims that have been made regarding the decisive role of epidemics and climate change.

In 2013, the economic historian Paolo Malanima wrote that "climatic phases marked the past history of mankind. […] While warm periods were favorable to the spread of cultivation and the multiplication of humankind, cold epochs coincided with periods of demographic decline. Roman civilization flourished in a period of warm climate and was accompanied by population increase, while the early Middle Ages was an age of demographic decline and cold climate." He continued by observing that pre-modern agricultural systems were relatively rigid and static in their supply of energy. Periods of warm climate allowed the expansion of cultivation into higher altitudes and increased population, since the volume of energy was rising. Hence, "the size of the population that could be fed increased remarkably."[2] In other words, warm periods increased the carrying capacity of the landscape and thus allowed populations to grow and prosper, while cold periods exactly did the opposite. The balance between land and population provides the link between climate change and Malthusian pressure, although climate change means that not only population is a varying factor, but that also the carrying capacity of the land varies independently of human action.

Some scholars hypothesize that Malthusian pressure caused living standards in the Roman Empire to decline, which made the population susceptible to the pandemic that hit the Roman world in 165 AD. Others have argued that this outbreak of infectious disease – known under the misleading name Antonine Plague – was an exogenous phenomenon, unrelated to the nutritious status of the population, but they too hold that it had a disastrous impact on Roman society, as did subsequent pandemics in the third and sixth centuries. John Brooke argues that epidemics were exogenous and at the same time decisive factors in determining population decline. However, there is an inherent conflict between models focusing on epidemics and those that assign a vital role to climate change. If indeed the Antonine Plague of the second century, the Cyprian Plague of the third and the Justinian Plague of the sixth to eighth centuries were exogenous events that significantly depressed population levels, like the Black Death would do in the 14th century, carrying capacity becomes less relevant, even irrelevant, until population regained its former level.

In order to assess the role of societal change, in the latter part of this paper we will zoom in on various regions in the Empire during the first millennium AD in order to show how their societies fared under changing climatic trends. The outcome of this exercise will lead us to reconsider the changes within human society that governed the workings of those economic, social and political institutions

[2] Paolo Malanima in A. Kander, P. Malanima and P. Warde, *Power to the people. Energy in Europe over the last five centuries*, Princeton 2013, 72-73.

that determined the extent of resilience and adaptability of each of these societies. The hypothesis will be that in the case of the Roman Empire phenomena that were within human control determined the impact of exogenous natural forces on society and that the pendulum must swing back again towards human agency and endogenous factors.

Chronologies of decline in the Roman Empire

We have at least to sketch the course of economic and demographic decline in the Roman world before we can turn to the fundamental causes. Two general remarks must be made at the outset: first, we cannot measure population or the size of the economy in absolute figures. We can only see relative change, which can be supported by very rough estimates. While most scholars agree on the trends, there is wide disagreement on the estimates. Second, the trends do not show the same chronology in all parts of the Roman Empire. Archaeology in combination with textual evidence shows three interrelated demographic trends from the early first millennium BC onwards throughout that part of the world that would become the Roman Empire: (1.) the number of sites of human habitation grew; (2.) the size of settlements, in particular of cities, increased; (3.) the exploitation of the countryside intensified. These trends show that both population and urbanization grew from the early first millennium BC onwards. In the western provinces, this trend ended around the turn of the second to the third century AD. In northern Africa, population and urbanization reached their peak in the fourth century, while in most of the eastern provinces population seem to have continued to grow until the sixth century, while the cities show no signs of decline. However, we should realize that even on the regional level there can be significant differences. For example, archaeology reveals a prosperous society in the city of Trier (Augusta Treverorum) and its hinterland in the fourth century AD, while at the same time the archaeological picture is bleak in the rest of northern and central Gaul, where towns, villas and villages seem to have almost vanished. Nevertheless, in general terms we may speak of similar trajectories within the western provinces, northern Africa and the eastern provinces.

With the attempt to bring the debate on the Roman economy on a firm, quantitative footing, scholars turned to proxies of the size of the economy. Many are by now familiar with such graphs as that of lead pollution in the Greenland ice-core and of shipwrecks along Roman shores, which all seem to show a peak in the second century AD. The significance of these graphs as indicators of economic performance has been overrated. In Wilson's revised shipwreck graph, the peak actually precedes the second century, but more importantly, the rapidly declining number of shipwrecks may be caused largely by the shifting of shipping routes to less investigated shores, while wrecks became less visible due to the increasing use of barrels instead of amphorae over the course of the imperial period. The lead pollution peak may reflect a peak in silver extraction in the Roman Empire, in particular Spain, but it is quite uncertain how this relates to economic performance. Other statistics, such as the number of public building projects and animal bones indicating meat consumption, are unreliable and show wide diversity throughout the empire. Hence, it is questionable whether the proxy data do indeed show a clear trend break that is valid for the entire Roman world. On the other hand, we may observe that in the early empire the scale of trade, the scale of so-called industries (although always characterized by relative small-scale production methods) and the number of imported goods at urban and rural sites increased. These trends show decline in the western provinces in the third century AD, in Africa in the fourth, and in most of the eastern provinces in the sixth century. In sum, if we are looking for

fundamental causes of economic and demographic decline in the Roman world, these must be able to explain the different chronologies in the various parts of the empire.

A Malthusian crisis?

Some scholars have argued that the long-term population growth from the early first millennium BC, leading to a classic Malthusian crisis, was the root cause of the decline. The Malthusian model may be summarized as a combination of various predictions based on the causal links between population, fertility, mortality, productivity and living standards:

1. Fertility rates move proportionally with living standards. In other words, if living standards rise, so will fertility; if living standards fall, so will fertility.
2. Mortality moves inversely proportionate to living standards. In other words, if living standards rise, mortality falls; if living standards fall, mortality rises.
3. All other elements being equal, living standards move inversely proportionate to population: if the population increases, average living standards will fall; if population declines, average living standards rise.
4. Living standards can only temporarily move away from the equilibrium level, as population growth will respond by either increasing in the case of rising living standards, or by falling in the case of declining living standards.

The last three are fundamental for the theory that the Roman Empire's demise was a Malthusian crisis, according to which the constraints on economic growth meant that the economy could not keep up pace with the demographic growth, leading to a decline of living standards. When living standards fell below a certain point, the population became malnourished and vulnerable to disease. Let us have a look at each of these three interconnected hypotheses.

First, did the constraints on economic growth mean that the economy could not keep up pace with demographic growth? Now, it would go too far to discuss the Roman economy in detail here, but we may briefly list the most important assumptions that lie at the heart of this mistaken hypothesis.[3] Absence of meaningful technological progress in classical antiquity supposedly constrained economic growth. Two objections should be made: recent studies have shown that technological progress was greater than traditionally assumed, the increasing implementation of water-powered installations in many productive sectors being the example most often cited. Such installations did indeed enhance available energy, but the significance of this should not be overestimated. In fact, the increasing size and power of oxen, which were the most important form of mobile energy in the ancient world, may have increased available energy in agriculture and transportation even more. However, the importance of technological progress should not be overrated to begin with. Structural change (or Smithian growth) in the Roman economy was even more important than the availability of new technologies. On the one hand, increasing market integration stimulated both regional and individual specialization, thereby increasing soil productivity and labour productivity. On the other hand, the growth of the non-agricultural sectors, which benefitted from urban markets and stable food supply, lowered the labor input in the land, as people found other means of subsistence. The transfer of labor from underemployment on the

[3] I refer to P. Erdkamp, 'Economic growth in the Roman Mediterranean world. An early good-bye to Malthus?', *Explorations in Economic History* 60 (2016) 1-20

land to more productive employment in other sectors contributed significantly to total production in the Roman world. In sum, it is not only possible that economic growth did for a long time outpace – or at least, keep up with – demographic growth, but in view of the indications of increasing consumption among large segments of the population, it is very likely that it did.

Second, do we see a decline in living standards? On the basis of anthropometric estimates of adult stature as a proxy for nutritional status it has been hypothesized that population density was an economically negative factor and that Malthusian theory cannot, therefore, be denied for the pre-1800 period. In their influential paper published in 2005, Koepke and Baten point out that the general assumption of economic growth should have meant rising living standards for the population of the Roman Empire. Instead, the long-term trend shows that stature was lower in the Roman period than afterwards. In fact, stature was inversely related to population density: when population density increased under Roman rule, stature fell, only to rise again after the end of the Roman Empire. Stature fell again with the population growth of the high Middle Ages, to rie again after the Black Death. The authors conclude that adult stature – in most cases deduced from the length of the femur bone – as a proxy for biological living standards reflects the workings of Malthusian pressure.[4] Other studies show as well that average stature was higher before the Roman Empire, that a peak in height occurred after the fall of the Roman Empire in the West and that people outside the empire were taller than those inside.[5]

Does indeed the graph of the change of average adult stature over time indicate Malthusian pressure on the living standards of the densely populated Roman Empire? Apart from the fact that adult stature is generally based on the length of the femur bone, the conversion of which may distort the data, the basic principle that body length is a valid proxy for biological living standards is questionable. Individual adult stature is partly determined by genetics, partly by a mix of diet, health, and physical exertion previous to adulthood. Potential body length is genetically determined, but children more often exposed to disease and subjected to hard physical labor will – all other circumstances being equal – realize this potential less than others. Equally important is the composition of the diet and in particular the consumption of animal proteins. Children consuming more meat and dairy products such as milk and cheese will on average grow taller than children whose diet contains less animal proteins. Obviously there is a difference in diet between rural and urban populations. Rural dwellers have more access to meat and other animal products than people living in cities, which is largely a question of pre-modern logistics. The higher population densities and lower urbanization rate of the pre- and post-Roman world left more room for livestock holding. Now, the point is that the data used by Koepke and Baten are not randomly selected and their conclusions therefore flawed. There are significant differences in the sample size of the various temporal and geographical backgrounds. Most seriously, due to the research practice of the archaeology of the Roman world, urban skeletons are overrepresented in the material for this period, while the skeletons for the earlier and later periods are predominantly rural. So, what the current graphs of stature mostly

[4] N. Koepke and J. Baten, 2005. 'The biological standard of living in Europe during the last two millennia', *European Review of Economic History* 9: 61-95.

[5] M. Giannecchini and J. Moggi-Cecchi (2008). "Stature in archaeological samples from Central Italy. Methodological issues and diachronic changes" in: *American Journal of Physical Anthropology* 135: 284-292.

show is that people living in a Roman city were generally shorter than people living in the countryside before or after the Roman period.

The difference in diet in itself may reflect a major difference in nutrition and health. It has often been argued that the inhabitants of the large cities of the ancient world were malnourished due to their cereal-dominated diet. In that case, urban dwellers were not simply shorter due to their cereal-dominated diet, but less healthy. Urbanization would in that case reflect a lowering of biological living standards. Due to the supposed nutritional shortcomings of a cereal-dominated diet, which was based on the analysis of modern types of cereals, scholars expected to find malnourishment among urban dwellers. It has been pointed out, though, that ancient cereals – or for that matter, all cereals and legumes from before the Green Revolution of the 20th century – were more nutritious in terms of minerals and vitamins than modern-day varieties, which are altered in order to optimize yields. It is now realized that the increase in yields was at the cost of nutritious value. Analysis of 19th-century varieties has proven this point, and analysis of samples from Roman Egypt will hopefully make the same point for ancient grain shortly.[6] At the end of the 20th century, the analysis of the skeletal and dental remains seemed to confirm the expected commonness of malnourishment in the Roman world. However, paleo-osteologists nowadays argue that markers of nutritional stress in bones and teeth are more often caused by genetic conditions, infectious diseases, parasites and even lead poisoning (the latter caused by lead pipes, in vessels, poorly glazed earthenware and pollution) than by inadequate diet.[7] In short, the image of the inhabitants of Roman cities as a malnourished crowd is in need of revision.

We have already partly addressed the third issue: did population pressure and a supposed impoverishment indeed cause a greater vulnerability to infectious disease and in increase of mortality? The Roman world offers few data to answer this questions, but comparative research in later and better documented societies shows that the link between the nutritional status of a population and its long-term demographic trend is far from straightforward. The main cause of death in the pre-modern world was infectious disease. The nutritious status of people did not affect their chance of dying, as the most serious killers were so very deadly that they did not distinguish between the rich and the poor, the well-fed and the malnourished. Even during a famine most people did not die of hunger, but of disorders that arose as a consequence of mobility and overcrowding. This picture is confirmed by the few detailed narratives of famines in the Roman world that we possess, whose authors all emphasize that the rich were not spared, as they died of the diseases that rose in the wake of hunger. Livi-Bacci pointed out that long-term trends in mortality seem very much unrelated to living standards, as in some societies mortality increased together with living standards, while, conversely, mortality ultimately declined in eighteenth and nineteenth-century Europe, when average living standard actually fell. Schofield makes the same point for Medieval England: despite the relative wealth of data – certainly compared to the ancient world – it is hard to pin down the causal link between nutrition and mortality. Walter Scheidel too has pointed out that the low life expectancy even under the higher classes of the Roman world indicates a high susceptibility to endemic diseases that were very much

[6] Preliminary results in F. Heinrich and P. Erdkamp, *Journal of Archaeological Science: Reports* (2017). http://dx.doi.org/10.1016/j.jasrep.2017.06.011

[7] K. Killgrove, 'Using Skeletal Remains as a Proxy for Roman Lifestyles. The Potential and Problems with osteological Reconstructions of Health, Diet, and Stature in Imperial Rome', in: C. Holleran and P. Erdkamp (eds.), *A Handbook to Diet and Nutrition in the Roman World*, London (forthcoming).

unaffected by the nutritious status of their potential victims.[8] In short, nutrition seems not to have been wholly absent in mortality and fertility, but long-term demographic trends were largely explained in terms of disease and fertility that are unrelated to diet.

The fact that decline set in first in the western provinces also argues against a Malthusian scenario of overpopulation, as the western provinces, where the most innovative forms of cultivation had only recently been introduced, were less densely inhabited and less intensively exploited than the East. We may conclude that neither theoretical considerations and comparative evidence nor the sparse data from the Roman world seem to support a Malthusian scenario in which the economy could not keep up with long-term population growth, leading to impoverishment and rising mortality. Thereby we have also settled the question whether the Antonine Plague was indeed a Malthusian crisis, but this pandemic, which hit the Roman world in the second half of the second century AD, merits a more detailed discussion.

The Antonine Plague: the exogenous beginning of the end?

The Antonine Plague hit the Roman Empire just about when things gradually began to change in Italy and the western provinces, so it is tempting to assume a causal link between the pandemic and the observed population decline (at least, in the west). John Brooke sees diseases and climate change as generally the main drivers of civilizational crisis, but in the case of the Roman Empire he actually assigns a greater role to epidemics than climate change. The reason for this is largely chronological: the onset of the Dark Age Intermediate Period (sometime after 300 AD) was simply too late to explain the decline of the Roman Empire, which according to Brooke began at the end of the 2nd century. In his view, the cause of the decline of the Roman Empire consisted of the series of devastating epidemics that started with the Antonine Plague. The Antonine Plague was followed in the mid-third century by the so-called Cyprian Plague, a widespread epidemic about which we know very little. In Brooke's view, these epidemics caused major population decline, which crippled the Roman Empire as it undermined military recruitment, economic demand, and political skill.[9] Brooke agrees with our conclusion above that the Antonine Plague was not an endogenous factor in the Malthusian sense. However, he links the epidemics to endemic warfare, as wars stimulated the occurrence and spread of epidemic diseases. At the center of the explanation for the decline and fall of the Roman Empire he identifies at first (that is, in the second century AD) the dynamics of war and epidemic, and at a later stage (sometime after 300 AD) the triad of war, epidemic and climate change.

Let us first start with what we know of the Antonine Plague, which is, alas, very little. Our sources tell us that Roman troops were infected by a mysterious disease while on campaign within the Parthian Empire. When they drew back into the Roman Empire in 165 AD, the disease soon affected the civilian population, rapidly spreading to neighboring regions and the capital city of Rome, from where in no time the disease moved to all corners of the empire. It is unknown from where exactly the disease originated, but it is clear that it was not limited to the Roman Empire. The pandemic continued to go in waves through the empire until the 180s. The nature of the disease was for a long time

[8] M. Livi-Bacci, 1991. *Population and nutrition. An essay on European demographic history*, Cambridge; P.R. Schofield, 2006. 'Medieval diet and demography', in: C.M. Woolgar et al. (eds.), *Food in medieval England. Diet and nutrition*, Oxford, 239-253; W. Scheidel, 2012. 'Physical well-being', in: W. Scheidel (ed.), *The Cambridge Companion to the Roman economy*, Cambridge, 321-333.

[9] Brooke 2014, 343.

uncertain, despite the descriptions given by contemporary physicians like Galen, but there seems to be consensus now that the pandemic consisted of an outbreak of the deadly variant of smallpox (*variola maior*). The identification is based on genomic evidence, which also indicates that the outbreak of 165 AD was the first occurrence of the disease in the western part of Eurasia.

The Antonine Plague is often compared to the Black Death, for which we have secure evidence that tells us that the 14th-century outbreak of the bubonic plague killed as much as one third of the population in many parts of Europe. Unfortunately, there is no secure evidence for the deadliness of either the Antonine or Cyprian Plague, as the ancient sources do not offer anything that is comparable to the medieval and early-modern documents. Our evidence is merely impressionistic, as various literary sources tell us that the pandemic affected the entire Roman world and caused many deaths wherever it struck. Hence, estimates of the demographic impact of the Antonine Plague vary greatly, as some reckon with the loss of no more than a few percent of the population, others assume up to 30 percent population loss within the two decades after the first outbreak. Those scholars supporting high mortality estimates have pointed to indirect indications, such as a slump in public building activity, but a careful re-investigation of the evidence by Bruun has shown that the drop in building activity is actually only very limited.[10] Moreover, the temporary reduction of imperial construction projects is adequately explained by the intense warfare that Marcus Aurelius faced after decades of relative peace. It has also been argued that the decrease in euergetic activity by urban elites at the end of the second century should be linked to the Antonine Plague: according to this argument, population decline meant a reduction of total economic activity and thus a loss of income of the urban elites, who therefore lacked the means to continue their euergetic expenditure. In other words, the decline in the construction of bathhouses, theaters, etc. and in the financing of urban foundations itself is seen as an indication of the severe population loss due to the Antonine Plague.[11] There are at least two problems with this argument: first, the decline in euergetic activity continued, while population levels recovered. Second, there are other factors that explain the long-term decline in euergetic activity, such as a change of mentality among urban elites, who felt less need to legitimize their role as ruling elites.

The most interesting indication of the severity of the epidemic consists of the fall in rents and land prices in Egypt during the last decades of the second century and a simultaneous, but very slight increase in real wages. Comparative research and economic theory predicts that when the land/people ratio changed, so did the value of land and labor. Hence, adherents of the high-mortality hypothesis interpret the fall in rents and land prices as the economic response to the fall in population in Egypt since 165 AD. The fact that real wages rose only slightly might be explained by the social and political structure of Egypt, which prevented laborers to profit from the relative increase in demand for labor. In 2002, Walter Scheidel pointed to these trends in wages and land value as indications of the impact of the Antonine Plague, but in a later re-appraisal he admits that the changes are only very slight. Hence, he warns against overemphasizing the demographic and economic impact of the plague.[12]

Brooke's hypothesis that, beginning with the Antonine Plague, the dynamics of warfare and epidemic caused the decline of the Roman Empire from around 200 AD does not really fit the

[10] C. Bruun, 2007. 'The Antonine Plague and the Third Century Crisis', in: O. Hekster et al. (eds.), Crises and the Roman Empire, Leiden, 201-218.
[11] Zuiderhoek (forthcoming).
[12] W. Scheidel, 2002. 'A model of demographic and economic change in Roman Egypt after the Antonine plague', *Journal of Roman Archaeology* 15: 97-114 W. Scheidel, 2012. 'Roman wellbeing and the economic consequences of the Antonine Plague', in: E. Lo Cascio (ed.), *L'impatto della "peste antonina"*, Bari, 265-295.

demographic, economic or military history. The connection between warfare and the pandemic of 165 AD seems only very loose. While the disease was indeed brought into the Roman Empire by an army withdrawing from the Parthian Empire, communication across the borders was so frequent that the pandemic surely would have spread into the Roman provinces anyway. After entering Syria, the disease was carried to Rome and every corner of the Empire along peaceful communication routes. Only a small part of the empire ever saw any kind of warfare during the decades before or after the outbreak of the Antonine Plague. The case seems a bit stronger for the so-called Cyprian Plague, which hit the Empire at a time of intense civil war, but a causal link between war and epidemic remains unsubstantiated. Brooke mentions various localized epidemics, frequently affecting Roman armies, but we should not forget that our literary sources are inclined to pay more attention to warzones than to peaceful provinces. Moreover, localized epidemics had regularly stricken Italy and the overseas regions in earlier centuries, when nobody would link them to military disruption or decline.

The Antonine and Cyprian Plagues left no trace in the archaeological record of Africa or the eastern provinces, while in the West it is difficult to establish on the basis of the archaeological evidence alone to what extent the first signs of economic and demographic contraction visible in some parts of the western provinces (but by no means everywhere!) at the turn of the second and third century AD should be ascribed to the effects of the pandemic. The absence of archaeological traces of the pandemic in the rest of the empire can either indicate the absence of any significant impact on population levels, or the insufficiently high resolution of the archaeological image of settlements patterns and the changes therein on the relatively short term. In any case, even if there was an impact on population levels or settlement patterns in Africa or the East, it was short-lived, as the peak regarding exploitation of the land and density of habitation in these regions was reached only in the fourth, respectively the fifth/sixth centuries. For what it is worth, the Christian theologian Tertullian from Carthage, who was born in the mid-2nd century AD and thus witnessed the pandemic, writes in the early 3rd century that the world was better cultivated, more densely populated and full of cities than ever before. So, Brooke's hypothesis that the Antonine Plague started the decline of the Roman world faces the challenge of explaining why the only signs of decline are visible in the western provinces, while prosperity and growth in the rest of the empire outlived both the Antonine and Cyprian Plagues.

One could argue that the Antonine Plague and following plagues were more severe in the western provinces than in Africa or the East, but that is not only special pleading, but also against all logic, as the conditions in the latter provinces favored the circulation of infectious diseases and frequency of epidemic outbreaks more than those in the West. High population density and the presence of large concentrations of people, in which the disease could become endemic, offered good conditions for an infectious disease to spread and recur. Not counting the deserts and mountain ranges, many parts of the East and north Africa were much more densely populated than the West, while, with the exception of the capital city of Rome itself, all cities big enough for the disease to become endemic were located in north Africa and the East. No city in the West even approached 100,000 inhabitants and thereby remained far too small to act as permanent disease pool from which to infect the countryside.

An alternative line of argument might be that the Antonine Plague triggered an economic response that ushered in a period of decline in the West, but not so in the East or Africa. In fact, Jongman argues that the Antonine Plague adversely affected levels of labor productivity and social

equality, leading to economic decline. However, he did not limit this phenomenon to the western provinces.[13] Again, I would like to avoid a detailed discussion of the Roman economy, but the argument seems based solely on the desire to link the Antonine Plague with the supposedly significant peak in several proxies at about the same time. If the Antonine Plague had been as deadly as Jongman supposes, the abandonment of marginal lands should have improved average soil productivity, while the shift in land/labour ratio increased the value of labour. Jongman argues that the latter did not happen, as landownership was increasingly concentrated in fewer hands and landowners intensified their stronghold on free labor. In order to be able to maintain their social and political spending, the elites increased levies and rents, resulting in impoverishment of the common people. Much of these assumptions are unsubstantiated or even contradictory to the evidence. Kyle Harper has shown that the theory of steadily increasing concentration of landownership, while often repeated, has actually no basis in the evidence, neither for the eastern provinces, nor for the west. Some Romans did indeed possess tremendously large estates, but not more so in the Later Roman Empire than in the early imperial period.[14] The debate on the late-imperial colonate has shown that there is no evidence for the restriction of the liberty of tenants and smallholders until the 4th century AD. The shift towards tenancy was a later phenomenon, while also the dwindling of capital-intensive villas only became significant in part of the western provinces from the second half of the 3rd century onwards. Taken together, there is no evidence for a structural shift in the Roman economy as a result of the Antonine Plague, neither in the East, nor in the West.

We must conclude that the Antonine Plague has been very much overrated as a breakpoint in the fate of the Roman Empire. The extent of population loss in the decades following its first outbreak is very uncertain at best. It is very unlikely that the Antonine Plague was more catastrophic in the western provinces than in the East, and there is no evidence for the hypothesis that the pandemic disrupted the economy in the west, but not in the east. In Africa and the eastern provinces, there is no visible demographic or economic slump in the aftermath of the Antonine Plague, while the size of cities, rural habitation or exploitation of the countryside retained their high level until the 4th, 5th and 6th centuries. In the western provinces we do see limited signs of contraction around the turn of the third century, but these are neither uniform nor omnipresent and can be linked, as we shall see, to other developments.

The next major pandemic occurred in the 6th century, when during the reign of the emperor Justinian the Eastern Roman Empire was struck by the Justinian Plague. The disease has been solidly identified as bubonic plague. Outbreaks of bubonic plague would scourge the Byzantine Empire and its neighbors until the 8th century, when the disease disappeared in order to reappear again in western Eurasia in the 14th century, with well-known catastrophic impact. The literary sources for the Justinian Plague are no better than those for the earlier pandemics, while the archaeology cannot offer clarity whether the perceived decline in cities and rural habitation in many parts of the East from the late 6th and early 7th centuries onwards was to a significant extent caused by the recurring waves of bubonic plague. Nevertheless, the argument for a detrimental impact of the Justinian Plague on demography

[13] W. Jongman, 2012. 'Roman economic change and the Antonine plague: endogenous, exogenous or what', in: E. Lo Cascio (ed.), *L'impatto della "peste antonina"*, Bari, 253-263.

[14] K. Harper, 'Landed wealth in the long term. Patterns, possibilities, evidence', in: P. Erdkamp, K. Verboven and A. Zuiderhoek (eds.), Ownership and exploitation of land and natural resources in the Roman world, Oxford 2015, 43-61.

and economy of the Byzantine Empire is much stronger than in the case of the Antonine Plague in the West. First, it occurred in the densely populated and highly urbanized regions of the eastern provinces and lasted for two centuries, unlike the relatively short-lived pandemics of the 2nd and 3rd centuries. Moreover, the Justinian Plague hit the East during wars that were much more widespread and intense than the wars waged by the Roman Empire at the time of the Antonine Plague. Brooke's theory of the dynamics of war and pandemic causing a fall in population and prosperity seems more valid for the late-Roman and early-Byzantine East than for the West in the second and third centuries AD. Whether the climatic Dark Ages were another element in a deadly triad remains to be seen.

Climatic Optimums and societal efflorescences

Books are still written on the fall of the Roman Empire that ignore climate as a noteworthy factor. In 2005, two major contributions to the study of the fall of the Roman Empire appeared: the monograph of the archaeologist Bryan Ward-Perkins and that of the historian Peter Heather. They have in common that they limit themselves to the realm of human action, while climate plays no role in their explanation of Roman decline. In 2013, archaeologist Esmonde Cleary published a book on the Roman West between 200 and 500 AD that discusses the military, the urban elites, the economy, Christianity, the 'barbarians' – but not climate. In contrast, three recent and influential publications emphasize climate change in the ancient world in relation to the rise and decline of the Roman Empire.[15] In an influential article written by a collective of historians, archaeologists and paleoclimatologists lead by Michael McCormick, we read: "The favorable and exceptionally stable [climatic] conditions that prevailed across the Roman Empire from c. 100 BC to c. 200 AD probably fostered the Empire's unparalleled rise." Climatic stability, it is emphasized, came to an end between 150-200 AD, i.e. at a time of economic, political and military stress. After ca. 400 AD, the variability in the climate increased in the West, with colder and wetter conditions. In the West, precipitation dropped sharply in first half 6th century, while in the 4th or 5th century, wet conditions returned for two centuries to at least major parts of the East. Hence, it is concluded, climatic conditions may help to explain the success of the Eastern Empire while the Roman Empire failed in the West.

Although Sturt Manning is more careful in his reconstruction of climate change, he too assigns a vital role to climatic conditions in bringing about the demise of the Roman world. During the Roman Optimum, from the 2nd century BC to the 2nd century AD, warm and humid climatic conditions in the Roman Empire reduced the risks to farmers and brought stability, offering the conditions for agricultural and demographic expansion. With the end of the Roman Optimum, however, agricultural uncertainty increased and bad years became more frequent. Central and northern Europe saw less favourable conditions arrive earlier than East. The more favorable conditions in the East, so Manning suggests, offer an explanation for the divergent trajectories of the Eastern and Western Empires.

[15] M. McCormick, U. Büntgen, M.A. Cane et al. 2012. 'Climate change during and after the Roman Empire. Reconstructing the past from scientific and historical evidence', *Journal of Interdisciplinary History* 43: 169-220; S.W. Manning, 'The Roman world and climate. Context, relevance of climate change, and some issues', in: W.V. Harris (ed.), *The ancient Mediterranean environment between science and history*, Leiden 2013, 103-170; J.L. Brooke, *Climate change and the course of global history. A rough journey*, Cambridge 2014. Also A.J. McMichael, 2017. *Climate change and the health of nations. Famines, fevers, and the fate of populations*, Oxford, sees climate change as the primary cause of the decline and fall of the Roman Empire. However, his argument is rather black/white and the books contains many errors of fact regarding the Roman world.

As we have seen, the explanation of John Brooke is less straightforward. In his view, the two exogenous factors of significant large-scale climate change and virgin-soil epidemics were decisive in bringing about the end of the Roman world. However, he notes that significant changes in the climate came too late to explain the beginning of economic decline, which in his view was primarily caused by the Antonine Plague, in combination with warfare. It is only at a later stage, in the 6th century, that severe and adverse climate change, partly triggered by volcanic eruptions, was added to warfare and epidemic to form a devastating triad that caused the fall of the Roman Empire. Nevertheless, Brooke also argues that climatic reversal around 300 AD – bringing cold, wet weather south through Europe – undermined what he calls the imperial agro-economy, while increasingly frequent drought in central Asia in the 4th century set peoples like Germans, Goths and Huns in motion, which embroiled the Roman world in a military struggle that the western empire would not survive.

In view of the temporal coincidence of human events and ecological trends, it is tempting to see the Roman Optimum as fundamental to the rise of the Roman Empire, and the same goes for the coincidence of the Bronze Age Optimum and the emergence of the Near Eastern palace economies, and the Medieval Optimum and the population growth of the 11th and 12th centuries. Following the same logic, the intermediate solar minima are seen as fundamental causes of societal decline (e.g. the pre-classical crisis starting around 1200 BC violently leading into the Iron Age or the Little Ice Age causing famine, revolt and war in the long 17th century). In such models, human societies over the past millennia have been passive subjects of exogenous solar and geological forces, only recently making sufficient institutional and technological progress to overcome the forces of nature. However, the studies of Michael McCormick et al., Sturt Manning and John Brooke all fail to identify and describe in detail the concrete causal links that go from colder or drier weather to the fall of empires. Reference to bad harvests, risks and rebellions seem sufficient explanation, although one could just as well argue that larger states, controlling a larger and more diverse territory, would be more successful in coping with increasing harvest volatility than smaller states. It also remains unclear how the rise of Rome is linked to the climatic optimum that is said to have begun sometime during the mid-Republic. The expansion of Rome clearly was at the cost of opponents both within Italy and the wider Mediterranean that experienced the same favorable conditions as Rome. Archaeological surveys have revealed the growing habitation in the countryside in Italy and the intensification of its exploitation from the third century onwards. This development may be linked to improving weather conditions, but also to the 'pacification' of the peninsula in the wake of Roman conquest.

Moreover, phenomena that do not nicely fit the chronological picture are often ignored. For example, the archaeology of Greece has shown that the population started to grow from the beginning of the 1st millennium BC, intensifying in the 8th century BC. This period of demographic growth coincided with the pre-classical crisis, a solar minimum that began with the demise of the Minoan and Mycenaean civilization and that is said to have lasted until 700/600 BC, with peak solar minima centering around 750 BC. In other words, population increased and settlements on the Greek mainland expanded into marginal lands precisely when climatic conditions were at their poorest. The point is that we should avoid easy assumptions about causal links between climate and society. Before we will zoom in on various regions in the Roman Empire in the first millennium AD, I will address some general issues concerning the impact of climate change on Roman society. To structure the argument, I will distinguish three levels: 1. climatic change; 2. the impact on landscape and agriculture; 3. societal response.

Climate change: some general considerations

Since we have no direct data on either temperature or precipitation for the premodern world, paleoclimatic research relies on different proxies that range from the chemical characteristics of Greenland ice or stalagmites, width of tree-rings, water-level and sediments of lakes, etc. Paleoclimatologists emphasize that most indicators can only be dated within a margin of several decades or even centuries, and this is the more the case the further one goes back in history. Many proxies for the ancient world offer insufficient resolution to link them to short-term societal events. Particularly risky is the combination of natural proxies and textual evidence, the more so when ancient written sources are primarily used to confirm hypotheses based on natural proxies. Ancient writers tend to pay more attention to extremes than to normality, but the reference to flooding or drought is not random. To begin with, the coverage of literary sources is not geographically or chronologically even. Certain times and places are covered better in the extent texts than others. We have more sources on early- or mid-imperial Palestine, for example, than on Anatolia, so droughts are mentioned more often for the first region than for the latter. Moreover, in ancient thought, natural disasters are linked to the condition of the times, which are perceived as affected by the gods and the actions of rulers. Hence, writers writing from a perspective of gloom and disaster will naturally tend to mention not only drought and drought-induced famine, but also locusts, diseases among man and animals, and unexplainable phenomena. The frequency with which extremes in weather are mentioned in our literary sources is a very uncertain indicator of climate change, and there is a great danger of circular reasoning, as political unrest may lead to more mention of extreme weather. Moreover, there is a tendency, at least among some scholars, to focus on extreme weather phenomena during periods in which they are expected. Brooke, for example, emphasizes the droughts in fourth-century Palestine, but fails to notice severe drought in the same region in the early imperial period, i.e. during the Roman Optimum, even though Flavius Josephus notes several droughts that affected both Judaea and its neighboring regions. In short, just as early-modern paintings of wintery landscapes or ice-skating Dutchmen do not prove the Little Ice Age, literary accounts of extreme weather cannot serve as evidence of climate change in Antiquity.

The labels of “Roman” or “Medieval Optimum”, described as eras of stable and warm climate, conjure up the image of centuries of endless good weather, with the reverse during the intermediate periods of climatic crisis (“Dark Ages”, “Little Ice Age”). The image is sometimes made explicit in phrases like “two centuries of severe drought” (Brooke, referring to 3200-3000 BC). In reality, annual fluctuations within a limited, regionally determined range of temperature and precipitation characterized all periods. This is best illustrated regarding the last few centuries, when we have fairly secure data. The graphs based on these data show wild annual fluctuations. The concept of climatic change refers to trends in these wild and seemingly random fluctuations, but these trends are far from apparent and readily discernible. In fact, the economic historians Kelly and ÓGráda have argued that there is actually no such trend as the ‘Little Ice Age’. In their view, the LIA is the result of statistical manipulation and not really present in the annual fluctuations of temperature and precipitation.[16] While this may go too far, their criticism demonstrates that climate change is a matter of subtle shifts in wildly fluctuating variables. There have never been eras of good or bad weather.

[16] M. Kelly and C. ÓGráda, 2014. ‘The Waning of the Little Ice Age: Climate Change in Early Modern Europe’, *Journal of Interdisciplinary History* 44: 301-325.

This also explains why the climatic periods used in the above studies do not seem to have clear temporal boundaries, which is exacerbated by the fact that many proxies cannot be dated precisely. Both the low resolution of data and the fuzziness of climatic periods contribute to the fact that Brooke, for example, has different beginning and end points for the same climatic period. The pre-classical climatic 'low' is said to last from 1300-700 BC, but also from 1200-600 BC or 1600-800 BC. The beginning of the Roman Optimum (Brooke calls it the Classical Optimum) is difficult to pin down (somewhere around 300 BC), but this is even more the case with its end, which is variously dated somewhere between the 3rd and 6th centuries AD. In view of the nature of the evidence and of climatic trends, this is reasonable and inevitable. However, it has severe methodological implications, in particular because many processes within human society are just as difficult to pin down. The emergence of states in the Near East or the decline of the Roman state cannot be dated to one year or decade, possibly not even to one century. So, while chronological coincidence seems to be the main basis for the assumed causal link, there is a danger that the coincidence of human events and climatic trends is the outcome of the observer's selection rather than present in the data. This makes claims regarding the causal link between processes in human society and climate both difficult to confirm and refute.

Some scholars might want to point out that some climatic events are clearly discernible in the proxies and in the statistical trends. Some years stand out in the data as exceptionally cold, sometimes with textual confirmation that the weather was dark and gloomy in those years. Indeed, we have to make a distinction between two kinds of climatic phenomena: on the one hand, long-term shifts that are caused by solar activity, shifts in the position of the Earth orbiting the sun (which happens on a scale of millennia), shifts in oceanic streams, etcetera, and on the other hand short-term phenomena caused by volcanic eruptions. There is sufficient evidence to show that the latter can cause abrupt changes in the weather, for example triggering cold and dark summers for a couple of years.[17] These events are severe, abrupt, but also short-lived. Longer-term events, on the scale of the Roman Optimum and the Dark Ages, are much more gradual, only noticeable in the subtle shift of averages and the frequency of extremes. For our estimation of the impact of climate on societal change, this is an important distinction, as volcanic eruptions may have an immediate, short-lived impact, but they do not adhere to wider trends and have no direct long-term consequences, while gradual long-term climatic changes occur on a time-scale that allows societies to adapt in ways that may even have been imperceptible to the peoples involved.

It is increasingly becoming clear, moreover, that there are significant spatial variations within larger-scale or global patterns. The current state of paleoclimatic research does not allow sufficient regional differentiation. The data deriving from different proxies are not easily combined, and while trends in these figures often concur, they do not always do so. Hence, S. Manning observed in 2013 that a coherent synthesis regarding the precipitation in the eastern Mediterranean after the 1st century AD was "impossible, as some data are simply contradictory".[18] While paleoclimatologists have meanwhile produced more data, the situation has not really changed. So, when Brooke describes climate change in terms of northern hemisphere, Eurasia, or even western and eastern Mediterranean, this might hide significant local variation. This severely weakens the argument regarding the climatic causes of the

[17] Regarding the so-called Dust Veil of 536 and the cold decade from 536-545 AD, see Izdebski et al. 2016, 194.

[18] S. Manning 2013, 160.

different fate of the East and West in Late Antiquity, which is primarily based on generalisations concerning climatic change in the eastern and western halve of the Mediterranean region.

Finally, paleoclimatologists agree that the climate change following the Roman Optimum was relatively limited. Brooke does not count the early medieval climatic depression among the major late-Holocene climatic 'lows', e.g. the Pre-classical crisis of the late Bronze Age/early Iron age, or the Little Ice Age of the early-modern period. McCormick stresses that the various proxies indicate a low degree of variability between 100 BC and 800 AD, while Manning observes that the changes in the 1st millennium AD were not of the same intensity as the changes of the 2nd millennium AD (i.e. the Medieval Optimum followed by the Little Ice Age).[19] In the present state of paleoclimatic research, the shifting trends regarding temperature and precipitation affecting the Roman world seem to have been relatively limited. This is important to keep in mind when judging the impact of climate change on society in this period.

The impact on landscape and agriculture

The weather undeniably plays a crucial role in interannual fluctuations of agricultural production, and gradual long-term changes in the pattern of temperature and precipitation therefore caused transformations in landscape, agriculture, food supply, and diet. Malanima summarizes the consequences of an enduring 1 degree Celsius drop in temperature. In temperate zones, the concomitant reduction in yearly hours of sunlight would decrease the growing period for crops, pastures and forests by approximately three weeks. In cold northern European regions, cereal production would become more difficult, while the marginal frontier of land was lowered by 150-200 meters.[20] Naturally, a rise in hours of sunlight and temperature would have a reverse effect. Consequently, Brooke argues that the warm, dry temperatures of the Roman Optimum favored the grain and wine economy of Mediterranean and allowed its expansion into central Europe. Conversely, the climatic reversal of around 300 AD brought cold and wet weather south through Europe, which undermined what he calls the "imperial agro-economy".[21] Archaeological studies have confirmed the effects of climate change on agricultural landscape and settlement pattern in some places. Settlements expanded into the Negev desert in humid periods, and it has been plausibly argued that the city of Petra in Roman times was surrounded by an agriculturally productive hinterland. In mountainous regions, changes in temperature probably caused the movement of agricultural cropping zones up or down the mountain slopes.

However, climate change has the greatest impact where conditions of temperature and precipitation are on the margins of biological requirements, such as on the fringes of deserts or on mountain slopes. The consequences of a reduction in yearly hours of sunlight, which are summarized by Malanima for temperate zones, were different in much of the Mediterranean lowlands, where the growing cycle of cereals and most other crops was determined by the avoidance of the hot and dry summer months. The agricultural handbooks of Cato, Varro and Columella tell us that, apart from farm land at higher altitudes, crops should be sown sufficiently early to avoid the summer drought. In many parts of Italy, wheat was sown in autumn and harvested in May or June. Hence, it is unlikely that in much of the Mediterranean lands there would be a detrimental effect of the reduction of sunlight in the form

[19] McCormick et al. 2012, 174; Manning 2013, 154.
[20] Malanima 2013, 40-41.
[21] Brooke 2014, 325-326.

of the shortening of the annual growing period. Horden & Purcell rightly emphasized the fragmentation of the Mediterranean into microregions and microclimates. As the agricultural writers emphasize, things were different in the mountain valleys, where crops were sown in the springtime in order to avoid the cold and heavy rainfall of winter. Regarding precipitation, the situation is equally varied. In much of the Mediterranean lands, an increase in average levels of rainfall might be beneficial to agriculture, if it occurred in the right time of the year and not in the form of torrential rainfall that would do more harm than good. On the other hand, more rain was potentially harmful on the farmland in higher altitudes, in particular on the western side of the mountain ranges of Italy and Greece, as depressions generally went from West to East and precipitation was highest on the western side of mountain ranges.

Moreover, it is not always easy to distinguish transformations in the landscape that were the result of variations in the climate from changes in the exploitation of the countryside. In some parts of Italy we see an increase of marshes and wetlands in Late Antiquity and the early Middle Ages, which may be ascribed either to increasing precipitation or to a neglect of drainage works by landowners and authorities. Imperial Rome created a huge and prosperous market for capital- and labor-intensive farms in its hinterland. The so-called suburbium was therefore densely populated and well-drained. When Rome's imperial grandness had disappeared and its population shrunken disastrously during the wars of the 6th century, its hinterland became depopulated and malaria-infested marshes returned. This may have little to do with climate change. Conversely, a reduction in agricultural activities in some marginal lands may be either the result of increasing drought or of the decline of irrigation. Shifts in markets and trade routes and in landownership affected the exploitation of the countryside, which made investment in irrigation worthwhile or not. This also means that, depending on social or economic conditions, adverse trends in the climate might have been compensated by increasing drainage or irrigation, or by the adaptation of cropping strategies. Drought-resistant cereals, such as barley or millet, limited the volatility of harvests. If farmers had sufficient access to outside sources of staple crops, an alternative response to a long-term fall in precipitation was the increasing cultivation of olive trees.[22] In sum, it is impossible to generalize, as Brooke does, that colder and wetter weather arriving in the Mediterranean lands after the Roman Optimum would be damaging to agriculture there. The same trend might have beneficial or detrimental effects – or few at all – dependent on the geographical conditions, and these might differ not only between regions, but also very locally, depending on altitude, soil, West or East direction, and so forth. Moreover, climate was an important factor in the exploitation of the countryside, but it was a factor among others, which, in the case of long-term change, offered some degree of resilience to farmers and society at large.

Climate and the fate of the Roman Empire

Sturt Manning already observed that climatic forcings may have varying effects on societal development. The link between climate and human history, if present at all, consists of complex, multifaceted, and multiscalar interactions that are contingent on social context and human agency.[23] Until now, studies of the role of climate change in human history seem to pay more attention to the intricacies of paleoclimatological methodology than to the creation of models that link climate and society. In response to the wild claims made in the global grand narratives, recent regional studies do warn against

[22] Thus observed for the Peloponnese in the first half of the first millennium BC by Weiberg et al. 2016, 47.

[23] S. Manning 2013, 104.

oversimplification of the causality between climate change and transformations in politics and economy. A recent special issue of the Quaternary Science Reviews on the Mediterranean region (on which more below) offers various regional studies that illustrate the absence of uniform responses of society to climate change. However, this has not lead to general models that elucidate the various linkages between climate, landscape, economy and political structure, the reason for which might be that in the real world the variables are simply too numerous to be captured in a generalized model.

Brooke makes the broad claim that the classical empires of the Old World were shaped by the Classical (Roman) Optimum running between the pre-classical crisis (ending variously 800/600 BC) and the cold episode of the Dark Ages (beginning 300/600 AD),[24] but he does not attempt to offer a model that clarifies the role of climate change in the course of global history. The most explicit model of causality in his book pertains to China in the first millennium AD, which may be due to the convenience of being able to relate strong/weak monsoons to the presence/absence of Chinese political unity and the fate of particular dynasties. There appears a tendency of climatic stability to coincide with political unity and dynastic stability, while floodings or droughts are linked to rebellions and dynastic upheavals.[25] Interestingly, the cooling of the northern hemisphere around 300 that ended the Roman Optimum is linked to the first proto-states emerging in Korea and Japan,[26] which leads one to question why the same trend is used to explain the rise of states on the one end of the Eurasian continent and the decline of the Roman state on the other. The forces at work in the Roman Empire on the political level are not spelled out.

The study by McCormick et al. explicitly ascribes the upheaval of the third century to climatic forces. Between 235 and 285 AD – i.e. the period of the so-called soldier-emperors, during which the Roman Empire saw almost endless civil war and the weakening of the central imperial authority in Rome – three to five major volcanic eruptions are said to have disrupted the food production within the empire. The fate of the empire is particularly linked to the Nile floods on which the grain harvests in Egypt depended. Egypt, it is argued, saw more abundant floods during the early empire (until 155 AD) than between 155 and 299 AD: "When the empire was at its zenith and the great grain fleets sailed north every year to the feed the capital and swell the cereal resources of the Empire, Egypt's productive farms seem to have enjoyed better Nile floods and therefore better harvests and fewer failed harvests."[27] The Nile floods were determined by the climatic system of eastern Africa and the Indian Ocean, which is not directly linked to that of the Mediterranean.[28] Most importantly, the implied link is not born out by a closer look at the economic and political situation. It would go too far to discuss the role of Egypt's grain in the functioning of the Roman Empire in detail here, but a few remarks may be made. To begin with, fluctuation of the Nile flood occurred throughout Antiquity, and exemptions to landowners in the case of insufficient flooding of their arable land was a vital element of the tax-system in Egypt. Second, the one significant harvest failure in Egypt that was discussed in detail in a Roman source occurred before 155 AD, during the reign of Trajan (98-117 AD). We are told that Rome sent grain to Egypt to alleviate the shortage there, while Trajan fought major expansive wars on the Danube and against the Parthian Empire. Third, Rome's income from Egypt in the form of tax-grain

[24] Brooke 2014, 323.

[25] Brooke 2014, 357.

[26] Brooke 2014, 327.

[27] McCormick et al. 2012, 189.

[28] Izdebski et al. 2016, 190.

exceeded in most years its needs for the capital and the armies stationed in the Mediterranean provinces. Most Roman armies, however, were beyond reach of Egypt's grain. The Egyptian tax-grain in excess of the direct imperial needs was made available to the authorities of cities in the eastern provinces. An increasing frequency in the failure of Egypt's grain harvest would have affected these cities more than the imperial authorities. Moreover, the most stress on the imperial needs was created by the foundation by Constantine the Great of a second imperial capital city in Constantinople, which was fed by tax-grain too. So, from the 320s onwards, Egypt's tax-grain was primarily allocated to the needs of Constantinople, while Rome now had to live off the grain produced by the provinces of Africa and Sicily. This indicates that the dependence of Rome on Egyptian grain should not be overestimated. Finally, if the detrimental impact of insufficient Nile floods would have had a devastating impact on the imperial control of grain, one would have expected the resulting political unrest and military strife to concentrate on Egypt, the major source of grain. However, Egypt does not play a major role in the civil wars of the third or fourth century. In fact, the majority of civil wars were fought between the military forces of Britain, the Rhine-provinces and those along the Danube, which were almost all beyond the reach of Egyptian grain. In short, while there may be a chronological coincidence between an increasing volatility of the Nile floods and the peak of political unrest in the Roman Empire, it is hard to causally link the two events.

Zooming in on climate change and society

Generalizations on the level of the western and eastern half of the Roman Empire are not useful and hence we have to zoom in on particular regions in the first millennium AD to establish which changes in landscape, agriculture and settlement pattern we do see that can either be linked to changing trends in temperature and precipitation, or to changes in the economic and political context, or, indeed, to a combination of both. We will have to limit ourselves to a few case-studies, based on recent research.

Levant and Syria

Throughout the East, proxies indicate a period of wet and probably warm conditions during the early imperial period up to 300 AD, followed by a decline in humidity that reached its nadir between 350-470 AD. At the same time, recent archaeological studies point to village growth, persistence of farmsteads and the emergence of large settlements in the late antique period. Regarding the Syrian Limestone Massif, we may quote a recent study: "A substantial demographic growth in ca. AD 330-550 (culminating in AD 450-530) was connected with an increase in the size of settlements and individual farms. Stagnation set in around AD 550-610; the ultimate decline took place in the 9th-10th century."[29] In other words, demographic and economic growth do not correspond withh climatic trends.

The relatively drier period of the 4th and 5th centuries was followed a wet phase that peaked in the 6th and 7th centuries. Izdebski et al. point to agricultural activity in the Negev in late antiquity, which today is too dry for rain-fed agriculture, but they observe that the expansion of settlement occurred before humidity increased, while it lasted after drier conditions set in (i.e. after about 670 AD). Hence,

[29] Izdebski et al. 2016, 191.

the authors conclude that political security and economic incentives that stimulated investments in irrigation were also vital for the development of agriculture in this region.[30]

Anatolia

The study by Izdebski et al. shows that climatic trends in Anatolia were very similar to those in the Levant and Syria. Anatolia saw expansion of rural settlement combined with agricultural intensification and specialization during Late Antiquity. The drier conditions of about 350-470 are linked to a greater frequency of subsistence crises in our written sources (however, see our critical remarks above), but the decline of precipitation is also said not to have brought about major societal change.[31] Decline in the form of land abandonment and settlement collapse came after 640 AD, but this cannot be linked to a reversal in climatic conditions at the time and is therefore ascribed to the disastrous Roman-Persian wars of the early 7th century, followed by the Arab conquest. The study of Izdebski et al. ends with the concluding remark that "climatic change thus played an important role in the major upheavals that brought about the end of Antiquity in the Eastern Mediterranean, but it was one factor among others, not a mono-causal explanation for societal transformation."[32]

Peloponnese

A recent study on the Peloponnese concludes that "there can be no general association made between societal expansion phases and periods of advantageous climate". "Local socio-political processes were probably always the key drivers behind the diverse strategies that human societies took in times of changing climate."[33] The researchers observe a clear difference in the settlement trajectories between the eastern and western Peloponnese during the Hellenistic and Roman period (300 BC – 300 AD), which are not ascribed to significant climatic variations, but to differences in the socio-political structures. The northeast of the Peloponnese shows a continued high number of sites even within the dry period indicated by local paleoclimatic proxies. The years between around 160-350 AD appear relatively wet, followed by several decades of drier conditions in the eastern Peloponnese. The western coast appears to have been wet between 550-800 AD, while the inland and east coast were drier in this period. The driest period in the east was around 650-700 AD. However, the increased aridity during the Late Roman and early Byzantine period "does not appear to have impeded the expanding cereal cultivation and rural settlement inland and in the eastern Peloponnese".[34] The final collapse of the late Roman economy occurred after 600 AD, but may be related not only to a peak in aridity, but also to the collapse of political institutions at the same time.[35]

Epirus

In contrast to the above case-studies, a study of a coastal region in modern Albania concludes that "phases of maximum settlement intensity in Butrint coincide with warmer and/or stable climate

[30] Izdebski et al. 2016, 202. However, they also note (p. 205) that a decline in cultivation in the Levant appears to precede the shift in climate to drier conditions.

[31] Izdebski et al. 2016, 205.

[32] Ibidem.

[33] Weiberg et al. 2016, 40.

[34] Weiberg et al. 2016, 51.

[35] Ibidem.

periods (0-800 AD and MCA [=Medieval Climate Anomaly], respectively), indicating a long-term influence of climatic conditions on human activities."[36] The evidence of the Lake Butrint points to a long period of relative stability between about the start of the Common Era to about 900 AD. However, within this period of stability, two distinct phases are identified: a generally warm and humid period up to about 400 AD, followed by an increase of moisture until about 900 AD.[37] However, the same study also notes "fresher conditions" than before or after in Butrint from 0-800 AD.[38] During this entire period, the region experienced a phase of maximum occupation, with a peak between about 400-550 AD. Sudden decline in habitation and exploitation in the 7th century is not linked to climate change, but to the wars against and conquest by the Slavs.

Sicily

A humid period from c. 450-750 AD was followed by a sudden period of aridity, which is linked to a phase of socio-economic and agricultural decline that lasted until about 1000 AD.[39] More generally, isotopes indicate on the one hand that the climate from about 0-1100 AD was on average wetter than afterwards; on the other hand that climate was rather stable during this entire period, with limited changes in humidity. In other words, the humid period of 450-750 was only moderately wetter than the centuries before or after.[40] It coincides with a period of intensive land use and high settlement density in both inland and coastal regions. The authors rightly point to societal factors for the economic intensification of Sicily during the Later Roman Empire: first, as we have seen, Rome lost access to Egyptian grain with the foundation of Constantinople in the 320s; second, the Vandal conquest of Africa in the 420s offered less control to the Roman authorities of this major supplier. While the city of Rome declined in the Byzantine-Gothic Wars of the 6th century, Sicily became a supplier of grain towards the Byzantine Empire, under whose authority it now fell.[41] Hence, favorable climatic conditions coincided with political and economic developments that increased the outside demand for agricultural crops.

On the other hand, economic decline in the 8th century coincides with the arrival of drier climatic conditions, and the authors suggest that this represents a "significant temporal correlation".[42] However, they also note that this decline "is the only case we were able to identify in which climatic fluctuations contributed to a major socio-economic change. During the Middle Ages, the drier conditions did not impede the agricultural recovery of the Norman period".[43] Hence, the decline of the 8th century should not be ascribed solely to a decrease in precipitation, but rather to the combination of less favorable climatic conditions and the absence of incentives to overcome these conditions, unlike the Norman period. The increasingly frequent attacks of Arabs offer sufficient explanation for the reluctance to invest capital in irrigation systems. In short, the climatic and human history of late

[36] Morellón et al. 2016, 134.

[37] Morellón et al. 2016, 146-147.

[38] Morellón et al. 2016, 149.

[39] Sadori et al. 2016, 173.

[40] Sadori et al. 2016, 177.

[41] Sadori et al. 2016, 180-181. See also Vaccaro 2015.

[42] Sadori et al. 2016, 182-183.

[43] Sadori et al. 2016, 186.

ancient and early medieval Sicily strengthens the hypothesis that climate change rarely in itself determined socio-economic developments.

Resilience in East and West

Although the impact of adverse trends in temperature and precipitation on agricultural production is neither straightforward nor uniform, it is likely that a reduction in sunlight, temperature or rain raised the frequency of bad harvests in those regions that were susceptible to these changes. While I reject the image of centuries of good or bad harvests that is invoked by the misleading terminology in some of the climate change-literature, variations in the volatility of harvests are entirely likely. However, harvest shocks are only one element in the food supply, the other element being the extent to which carry-over and distribution in the form of market and non-market mechanisms are able to alleviate the impact of annual harvest fluctuations. In other words, not only climate change is important, but also the resilience of society to deal with its adverse effects. The hypothesis proposed here is that the economic decline in the West from the third century AD onwards, in contrast to the continued prosperity in the East, was due to the weakening of those commercial and socio-political mechanisms that at the zenith of the empire in the West had succeeded in alleviating local harvest shocks. This is not to say that public and private mechanisms had previously always succeeded in preventing food shortages, as disastrous famines did occur in East and West at all times, though not in the political centers like Rome itself, which could count on imperial intervention until the very end of the western empire. The impact of the weakening of these mechanisms went beyond the food supply, as it triggered the spiraling down of the entire urban and rural economy. We will sketch this process in the following, focusing particularly on Gaul.

The configuration of economic determinants in the western provinces during the early empire favored economic growth and complexity. The towns and cities, but also the armies on the Rhine frontier, offered stable markets for a wide range of goods and services, stimulating market-oriented agricultural enterprises that generated large and relatively stable surpluses. The numerous villas produced foodstuffs and raw materials for the non-agricultural sectors, which were in turn stimulated by the presence of prosperous markets for raw materials and finished goods. The growth of the non-agricultural sectors allowed the productive employment of a larger share of available labor in the countryside, and all this was made possible by the increased market integration that was stimulated by Roman pacification and infrastructure and by the relative urban price stability underwritten by civic-minded ruling elites. We should not exaggerate the prosperity and stability of urban and rural society, nor underestimate the extent of social inequality that allowed a small segment of society to reap most of the rewards of economic growth, but this was a society in which numerous cash-crop farmers, shopkeepers and artisans in towns and *vici* deemed their small businesses sufficiently stable as to wage their households subsistence on them.

The state had a significant role in the distribution network that underpinned economic growth, as the Roman armies on the Rhine and upper Danube were supplied with large volumes of Mediterranean goods, including olive oil from Spain and wine from southern Gaul. Ships and river boats bringing army provisions to the North did not go back empty, so even if the state-induced transportation was basically one-way, it stimulated also distribution the other way. Moreover, ships not only carried state-goods, but also commercial cargo, such as the fine pottery of La Graufesenque or other workshops, whose products during the early empire could be found all over the western

Mediterranean. The traders and shippers involved in this network organized themselves in order to deal with the authorities and to reduce their transaction costs.[44] The military supply-network thus not only stimulated market integration through its infrastructure and the movement of ships, but also through the connections and communication it provided. We may refer here to two *decuriones* (town councilors) from Gaul who honored their *amicus et sodalis* (friend and partner) for his contribution to the food supply of their home-town. The latter was a citizen from Carthago Nova who was possibly involved in provisioning the Roman armies along the Rhine.[45] In short, the merchants and shippers that were involved in the supply-chain between the Mediterranean on the one hand, and the army camps and cities on the frontiers on the other stimulated communication and trade throughout this wider region. Since information and communication are as important to market integration as harbor facilities, the state contributed to creating the circumstances needed to increase the economic performance in this part of the Roman world.

Warfare only became chronic within the western provinces in the mid-third century, but from the reign of Marcus Aurelius (161-180 AD) onwards, the military situation within the Roman Empire changed sufficiently to gradually and slowly impair the conditions of commerce and trade. The intensity of external war had changed, as Rome now regularly had to wage serious wars on several fronts at the same time, with civil war adding to the burden in the 190s and from the 230s onwards almost permanently. The first major change that we see, around the turn of the second and third century, is the dwindling of the provisioning of Mediterranean supplies to the Rhine frontier. By 300 the provisioning had come to a complete halt. The causes for this development have to be sought at least partly in the changing ethnic composition of the legions stationed along the Rhine and *limes*, as the troops were increasingly recruited from the frontier zone rather than from the Mediterranean lands. Hence, dietary preferences of the troops had changed, and olive oil was probably being replaced with butter or lard, while wine now largely came from central Gaul. For Gaul it meant a shrinking of the state-supported supply network, which must have had a negative impact on the conditions of trade and communication in the region. We see this reflected in the third century in the much reduced distribution radius of the fine pottery produced in Gaul.

Around the turn of the second and third century we also see a slump in the activities that traditionally reflected and propagated the civic-mindedness of the urban elites. In the late first and second century the provincial towns and cities had witnessed an upsurge in the construction of public buildings and monuments that characterized the Roman city in the West, like forum, temples, theatres and bath-houses, partly paid by the public funds of the towns, partly by the munificence of the leading families. Benefactions and civic spending on the food supply, festivals and public buildings were part of their legitimation as ruling elite and a way to emphasize their social status. In the early empire, members of the ruling families, either as state officials or as private benefactors, regularly intervened in the urban food supply during shortages by making grain available at reduced (if still high) prices or by arranging for outside grain to be shipped in. At the end of the second century, however, the drive to finance civic projects came to a standstill, which is reflected in a slump in the public inscriptions that advertise the public role of the members of the ruling elites. Esmonde Cleary ascribes this development to a lessening of the need the leading families felt to confirm and legitimize their social and political

[44] One interesting case involves five *corpora* of shippers from Arles (*corpus navicularii marini Arelatenses*), known from an inscription (*CIL* III 14165/8) from 201.

[45] AE 1979, 434 = Dardaine and Pavis D'Escurac (1986) nr. 12. Also, p. 296.

status, which affected their inclination to invest money in public monuments.[46] We see this development not only in Gaul, but also in Spain, where from the second half of the second century onwards, ruling families did not find it useful anymore to inscribe their functions and deeds in stone.[47] Hence, the attitude of the urban elites towards their civic responsibilities had significantly changed by the start of the third century.

Both developments – the dwindling of the imperial supply network and of the civic mindedness of local elites – increased the vulnerability of the urban populace to price volatility. Economic circumstances therefore significantly worsened even before continuous and large-scale warfare reached the Roman West. The frontier wars and civil strife of the mid-third century catalyzed the downward spiraling of the economy. By the end of the third century it was undoubtedly much harder to alleviate the impact of a local harvest failure than 150 years earlier. Although we lack price data to confirm the hypothesis, we may be certain that price volatility increased disastrously in regions regularly affected by external and internal warfare. The risks increased particularly for those involved in the non-agricultural sectors, as in times of shortage they were confronted with both high food prices and a slump in the market for their own products. We see this reflected in the rural habitation pattern, as the *vici*, nucleated settlements of artisans and small-scale traders, which were omnipresent in the early empire, disappeared from the late Roman countryside. The uprising of the so-called Bagaudae in fourth-century northern Gaul was triggered by the poverty and hardships among the rural populace and inhabitants of small towns. Shrinking towns and cities in the West from the mid-third century onwards meant a decline in urban markets for goods and labor. As the wider economy shrank and employment opportunities in the non-agricultural sectors declined, proportionately more people worked the land. The earlier trend reversed and productive labor in urban and rural non-agricultural sectors were shifted again to higher levels of underemployment and lower levels of productivity on the land. Capital-intensive forms of direct exploitation became less attractive, while small-scale tenant households gradually started to play a greater role, relative to servile workforces, on the estates of large-landowners. Inevitable consequences of the structural shift in agriculture towards small-scale tenancy were lower levels and greater volatility of surplus production. Hence, the vanishing of urban markets went hand in hand with the decline in surplus production.

In contrast to the West, which showed decline on all counts, high levels of population and urbanization, market-oriented farms, large-scale distribution, and the mass-consumption of the products of artisans continued to characterize the economy of the East. Since Hellenistic times, the East and Africa boasted cities exceeding 100,000 inhabitants, only surpassed by late-Republican Rome on the basis of its vastly greater political power. The western provinces never counted a city of such a size. Economic performance in the West was less based on mega-cities and more directly connected to the state, in particular the army and the apparatus supporting the army, while the East had large cities that continued to function as catalysts fueling the economic chain-reaction of market and production. Until the 6th century, the East does not show any decline regarding the range of goods produced, the geographical scale of its distribution, or the extent to which it penetrated rural and poorer segments of society.[48] Despite political instability and the increasing burden of the armies, the mega-cities kept the East and Africa from spiraling downwards. They not only ensured a continuing

[46] Esmonde Cleary 458-459.

[47] Esmonde Cleary 111.

[48] Ward-Perkins 2005, 104-108, 123-127.

market for artisans and commercial farmers in the fifth and sixth centuries, but state-induced distribution networks maintained the relative price stability, infrastructure and flow of information and communication that were necessary for the wider economy to prosper.

Conclusions

The previous discussion intends to show that endogenous factors and the success or failure of society to deal with changing circumstances are at least as important – and in the case of the fall of the Roman Empire in the West, even more important – than Malthusian pressure, epidemics or climate change. The Roman world was not constrained by Malthusian limitations. For a few centuries economic growth outpaced demographic growth. Even if per capita growth was not spread evenly among Rome's subjects, significant segments of society profited from higher living standards and wider consumption choices. There is no sign that the Roman world hit a Malthusian ceiling, resulting in declining living standards, though average living standards certainly fell in parts of the West from the third century onwards. Pandemics were endogenous in the sense that increasing population density, urbanization and mobility offered better circumstances for infectious disease to spread throughout the Roman world. However, they were exogenous in the sense that they did not occur as a result of lowering living standards and nutritional status. The often assumed disastrous impact of the relatively short-lived epidemics of the second and third centuries on population levels and prosperity of the empire is unsubstantiated. Decline is not visible in the provinces of Africa and the East, while it is unlikely that the Antonine and Cyprian Plagues would have affected the relatively thinly populated and less urbanized West more than the rest of the empire. There is more justification to assume that the Justinian Plague that lasted from the 6th to the 8th centuries had a devastating impact on the early Byzantine Empire.

The political and economic circumstances that triggered growth in the West turned out to be fragile, depending on the particular configuration of the functioning of the Roman state and the mentality of a ruling elite - a mentality that in the West rapidly changed when the civic-mindedness of the classical polis became an anachronism. The West did not reach the limits of the carrying capacity of the land, and under different circumstances the advances in agricultural productivity could have continued. There is no reason to assume that the political and military unrest of the third century was related to increasing pressure on limited resources. It is an oversimplification to argue that climate change lowered the carrying capacity of the Roman world, causing a breakdown of the political institutions and economic structures of the Roman state. Paleoclimatic indicators show that changing trends in precipitation and temperature that affected agriculture are undeniable, but patterns are less clear and changes less severe than recent publication claim. Recent long-term regional studies show that changes in society do not always conform to general assumptions regarding the impact of climate, which confirms that, despite Malanima's bold claim, human society was not the passive subject of climatic conditions. Beneficial climatic conditions generally allowed expansion of exploitation and habitation, but the reverse was far from inevitable. Societal circumstances determined whether drainage, irrigation or changes in cropping strategies overcame adverse natural conditions. Climate change may have caused an increase in the frequency of harvest failures in the West, but far more damaging was the declining ability of society to alleviate the impact of harvest shocks on the food supply, the wider effects of which triggered the spiraling down of the economy of the West.