Lecture 3: Earth's Climate

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- Lessons from Africa's long history of climate adaptation for present and future responses to climate change.

Aims

This lecture aims to situate human history within Earth's long climatic trajectory, with a particular emphasis on Africa as both evolutionary cradle and laboratory of climatic adaptation. Students are introduced to the interplay of orbital forcing, atmospheric CO_2 dynamics, and regional ecological shifts in shaping both global patterns and African-specific developments. By engaging with the archaeological and palaeoclimatic record, the lecture seeks to show how hominin evolution, agricultural transitions, and complex societies were inextricably linked to climate variability. It further aims to highlight the significance of indigenous African crops and adaptive strategies as historical resources for thinking about contemporary and future climate resilience.

Learning Outcomes

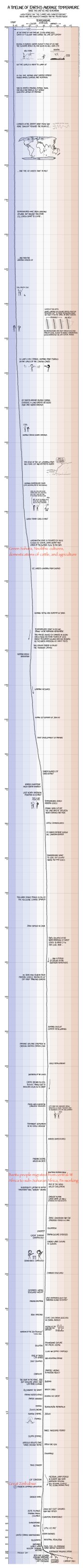
By the end of the lecture, students should be able to:

1. Outline the major phases of Earth's climatic history over the last 20,000 years and describe their relationship to human dispersal and cultural change.
2. Explain the mechanisms of orbital forcing (Milankovitch cycles) and their role in glacial–interglacial transitions.
3. Assess how climatic variability shaped early hominin evolution and dispersals in Africa from the Miocene through the Pleistocene.
4. Describe the environmental and social conditions underlying the Agricultural Revolution, the African Humid Period, and subsequent aridification.
5. Analyse the connections between crop domestication (millet, sorghum, yams, African rice) and the development of African societies, including the Bantu expansion and the rise of urban centres.
6. Evaluate the impact of climate events such as the Toba eruption, the Medieval Warm Period, and the Little Ice Age on African societies.
7. Critically reflect on how Africa's long-term adaptive strategies—ecological flexibility, diversified livelihoods, and social resilience—can inform responses to modern climate change.

1 A Brief History of Earth's Climate and Human Civilisation

On the left axis of the graph below (actually the x-axis due to the orientation we've got here) we have the independent variable, and on the horizontal axis, that's the dependent variable. Here, temperature is the aspect that depends on which point in history we're examining. The graph spans from +4 °C to −4 four °C, relative to the average temperature over the entire depicted period. Now, the main focus is on this central white band, which is key for our discussion.

I explain the content of the scrolling figure below the image.


A TIMELINE OF EARTH'S AVERAGE TEMPERATURE
SINCE THE LAST ICE AGE GLACIATION
Green Sahara, Neolithic cultures, domestications of cattle, and agriculture
Bantu people migrated from central-W Africa to sub-Saharan Africa, re-working
Great Zimbabwe

1.1 In the Beginning

The timeline starts at around 20,000 years ago, and as I scroll down, we move steadily towards the present day. So, about 20,000 years ago, Earth was roughly 4 °C colder than it is today. I must point out that this is quite a Northern Hemisphere-centric perspective. At some point, I should really produce a similar graphic focusing on South Africa or the African continent, so we can localise our interpretations. For the moment, however, do keep in mind that this particular presentation is fundamentally rooted in North American context.

UPDATE: I have now created a similar deep-time perspective for Africa (see Section 2), but I must still make a comparable graphic.

At that time, Boston—now a relatively verdant city—was actually buried under about a mile of ice. So, back then, the temperature was still about four °C colder than present, and that's reflected by the dotted line tracing temperature changes. From here on, the graph outlines a chronological procession of climate events and human developments.

1.2 Early Human Migrations and Extinctions

Between 19,000 and 19,500 years ago, humans had already dispersed from Africa and were found throughout Eurasia and even in Australia. Notably, when humans arrived in Australia, their sudden presence led, within around a thousand years, to the extinction of all the large mammals—megafauna—in that region. Today, the largest animals in Australia are kangaroos, but prior to human arrival, truly massive creatures inhabited the continent. The arrival of humans is strongly linked to the rapid die-off of these species. This phenomenon is not unique to Australia; similar patterns were happening elsewhere, including South Africa.

Around 19,000 years ago, evidence shows that people began to create paintings, pottery, rope, and other artefacts of material culture.

1.3 Climatic Shifts and the Milankovitch Cycle

At approximately 18,500 years ago, there was a slight change in the Earth's orbit—a phenomenon known as the Milankovitch cycle. This event caused Earth to absorb a little more heat in its polar regions, which in turn allowed the great ice sheets to begin melting. The process was gradual at first: as the ice sheets retreated, sea levels rose, but temperature increases remained relatively modest. However, atmospheric CO_2 concentrations began to creep upwards. This was due to various processes, including the re-mineralisation of materials previously trapped beneath the ice.

As more naturally trapped CO_2 entered the atmosphere, warming began to accelerate, though it remained cold by modern standards—still about three °C colder than today.

1.4 Human Culture and Dispersal

By 15,000 years ago, we see the emergence of cave art—the kind that we now admire as cave paintings, though at the time, people might simply have seen it as graffiti. Some of the oldest examples have been found in France.

At around 14,500 years ago, the ice sheets in Alaska shrank to the extent that the land bridge between Asia and North America, the well-known Bering Land Bridge, disappeared. This development made it possible for humans to enter and populate North America for the first time, giving rise to the ancestors of Native Americans. This migration predates the arrival of Europeans on the continent by many thousands of years.

By 13,500 years ago, New York was no longer under ice, and by 13,000 years ago, species such as the woolly rhinoceros became extinct. At 12,500 years ago, significant flooding occurred in what is now Washington state, due primarily to the rapid melting of glaciers.

1.5 Rise in CO_2 and Continuing Warming

All the while, CO_2 levels continued to rise, driving further increases in temperature. The ice sheets eventually disappeared even from areas such as Chicago.

By 11,500 years ago, people began to settle in the area now called Syria—formerly known as Mesopotamia—within the region known as the Fertile Crescent. This marks a pivotal point, as humans began to establish small communities and, ultimately, towns and cities. The city of Jericho, one of the earliest known urban settlements, arose during this era, when the Earth's temperature was still about one and a half °C colder than present.

1.6 Agricultural Revolution and the Holocene

Moving to 10,000 years ago, as temperatures reached a level still somewhat cooler than modern conditions, the first evidence of farming emerges. People first settled in cities and only then does agriculture appear, in response to the demands of a growing, settled population.

About 9,500 years ago, or more specifically around 9,200 years ago, we see the extinction of the sabre-toothed cat. Horses also disappeared from North America, likely due to human impacts. (A quick aside: there's a facetious reference in the scrolling figure to Pokémon going extinct at this time, which is, of course, entirely fictional.) As temperatures reached levels comparable to those of the 20th century, cattle were domesticated—around 8,500 years ago. By this point, the ice sheet over Canada had entirely vanished.

From roughly 10,000 years ago to the present, Earth's temperature remained, for the most part, within a relatively narrow band—about one degree Celsius higher or lower than today. This stable period is known as the Holocene. It encompasses the entire span during which humans have been able to build cities, develop stable agriculture, and domesticate animals.

1.7 Early Civilisations and Technological Developments

By about 7,000 years ago, human settlement is documented in China, which stands as the oldest continuous civilisation in the world. Around 7,500 years ago (5,500 BCE plus the succeeding two thousand years), metalworking begins, along with the invention of the wheel, which, surprisingly, dates to only about 6,000 years ago.

The timeline features several key developments in civilisation—urban life in the Fertile Crescent; Egyptian mummification; the rise of the Indus Valley civilisation; and later, Stonehenge in the UK at about 4,000 years ago. Alphabetic writing appears in Egypt after the development of chariots and further urban expansion.

Written history, iron smelting, and early Greek civilisations also belong to this relatively recent part of our timeline. The peopling of the Pacific and Solomon Islands follows, and then another sequence of events from classical Greece to around 500 BCE, when both Greek and Buddhist traditions were crystallising.

1.8 Recent History, the Industrial Revolution, and Climate Change

All of the above—essentially everything we know as "civilisation" and "recorded history"—has taken place within this narrow "white band" on the graph, where global temperatures have not deviated by more than about one degree Celsius from present values.

Fast-forwarding to the last few centuries, we reach the invention of the steam engine, which allowed humanity, for the first time, to convert heat energy into mechanical work efficiently—driving the Industrial Revolution. Before this, societies had depended primarily on human and animal labour. Subsequently, developments such as the telegraph and aeroplane emerged, propelling us into the modern era.

Now, as of 2016, we find ourselves not only at the edge of this narrow band but potentially at the threshold of something new. Should we persist with current patterns of fossil fuel combustion—coal, oil, and gas—we are on a trajectory that leads to much warmer global temperatures, with increases possibly in the range of two, three, four, or even five °C above current levels. If, on the other hand, we made a radical change—literally switching off all fossil fuel emissions overnight—we might have a chance to slow the warming, but even then we are now in a climatic regime where no human civilisation has ever previously existed.

2 An African Deep-time Perspective

Much of the information below comes from an excellent book by Reader (1997). I'd highly recommend that you get yourself a copy and read it. It is a very accessible and engaging synthesis of Africa's deep history, from its geological origins to the present day.

Reader's "Africa: A Biography of the Continent" is less a conventional history (more of a geo-biohistory) of Africa. It is an expansive deep-time reconstruction of the continent's entanglement with geology, climate, and biology. Reader traces its tectonic origin story, the emergence of hominins, and the recurrent reshaping of landscapes under climatic stress. The narrative is cohesive and insists that human evolutionary (in terms of the species, and of human societies and cultures) trajectories here cannot be disentangled from shifting rainfall patterns, rift valleys, deserts encroaching and retreating deserts, and fertile zones that appear and vanish across millennia. The book's makes visible the continent's long ecological duration, within which political formations are only one layer. It reads as both archive and argument, and the conclusion is that to understand Africa, one has to see history itself as adaptation to the deep climatic rhythms of Earth.

2.1 ~7–6 million years ago (Late Miocene cooling and aridification)

This interval includes the divergence of the human lineage from other apes in Africa. In Chad, *Sahelanthropus tchadensis* (c. 7 Ma) and in Kenya, *Orrorin tugenensis* (c. 6 Ma) appeared during a period of great climatic transformation. The Late Miocene cooling created a mosaic environment of open grassland, wooded savanna, fresh water areas, and gallery forest remnants. This climatic drying across East Africa led to the retreat of dense forests and the spread of savannahs, a transformation that was central to the ecological pressures that shaped early hominin evolution. The mammalian fauna from this period indicates that despite regional aridity, water sources and varied habitats supported a rich biodiversity, creating the environmental context in which our earliest ancestors took their first steps toward bipedalism.

2.2 6–4 million years ago (Continued aridification and hominin diversification)

During this period, progressive climatic cooling continued the transformation of African landscapes. The establishment of more seasonal rainfall patterns created challenges that early hominins had to navigate. *Ardipithecus* species emerged during this time, showing adaptations to increasingly diverse environments that included both forest remnants and expanding grasslands. The alternating wet and dry cycles characteristic of this period may have been instrumental in driving the evolution of flexible locomotion strategies, as early hominins needed to access resources across varied terrains.

2.3 4–2 million years ago (Pliocene warmth transitioning to Quaternary variability)

The continent saw the rise of *Australopithecus afarensis* (the famous "Lucy," c. 3.2 Ma) and later *Australopithecus africanus* during a time of significant climatic oscillation. The Pliocene of East Africa was generally warm and wet compared to the preceding Miocene, with extended rainy seasons lasting about eight months. These climatic conditions supported diverse habitats including open grasslands, woodlands, shrublands, and lake- or riverside forests. *A. afarensis* showed remarkable environmental adaptability, inhabiting this wide range of habitats for nearly a million years. The fluctuating climate, oscillating between wetter and drier periods, shaped Rift Valley landscapes and pressured hominins into developing diverse dietary and technological adaptations. Around 3.5-4 million years ago, a warm period with temperatures 3°C higher than today provided abundant resources, but the subsequent cooling trend beginning around 2.8 million years ago created new evolutionary pressures.

> **i** Food crops: ~7–2 million years ago (Late Miocene to Pliocene)
>
> During the early hominin periods, John Reader notes the existence of a mosaic environment of open grassland, wooded savanna, and forests. The mode of living for early hominins like *Sahelanthropus*, *Orrorin*, and *Australopithecus afarensis* was primarily foraging and gathering, likely focusing on plant resources like fruits, leaves, and tubers, as well as insects and other small animals. Reader stresses that the fluctuating climate, oscillating between wetter and drier periods, shaped landscapes and pressured hominins into developing diverse dietary and technological adaptations to exploit these varied resources. This environmental pressure likely fostered a flexible, non-specialised diet that was key to survival across different habitats.

2.4 ~2 million years ago (Early Pleistocene cooling trend)

The appearance of *Homo erectus* in Africa coincided with a sharp climatic instability and the establishment of glacial-interglacial cycles. Archaeological sites like Koobi Fora in Kenya and evidence from Dmanisi suggest that around this time, hominins began controlling fire—a key technological adaptation that would prove essential for surviving increasingly variable climates. The progressive cooling and aridification during this period created selective pressures that favoured larger-brained hominins capable of more sophisticated tool use and social cooperation. The emergence of *Homo erectus* represented biological evolution and the beginning of active environmental manipulation through technology. This period also saw the first major dispersals from Africa, as hominins followed environmental corridors created by climatic fluctuations.

2.5 1 million–300,000 years ago (Middle Pleistocene climate instability and hominin evolution)

This period was characterised by intensifying glacial-interglacial cycles that created complex environmental challenges across Africa. Around 700,000 years ago, *Homo erectus* populations in Africa began evolving larger brains and more sophisticated cultural adaptations, leading to new hominin forms. The most profound shift in African hydroclimate of the last million years occurred around 300,000 years ago and involved an east-west change in moisture balance that cannot be fully explained by high latitude climate systems alone. Instead, this shift was driven by changes in the tropical Walker Circulation related to orbital forcing. Western Africa became relatively drier while eastern Africa became wetter, fundamentally altering the distribution of resources across the continent. This climatic reorganisation coincided with the emergence of new hominin technologies and behaviours, suggesting that environmental pressures continued to drive evolutionary innovation.

> **i** Food crops: ~2 million–300,000 years ago (Early to Middle Pleistocene)
>
> The appearance of *Homo erectus* coincided with increased climatic instability and the establishment of glacial-interglacial cycles. Reader mentions that these pressures favoured larger-brained hominins capable of more sophisticated tool use and social cooperation. The mode of living shifted towards more active hunting and gathering. The control of fire, a key technological adaptation mentioned in the text, would have allowed for the cooking of meat and plant foods, increasing digestibility and energy intake. This technological and social evolution enabled *Homo erectus* to exploit a wider range of food sources and led to the first major dispersals from Africa.

2.6 ~315,000–200,000 years ago (Early *Homo sapiens* emergence during climatic transition)

In Morocco, fossils from Jebel Irhoud dated to ~315,000 years represent some of the earliest known anatomically modern humans. These populations emerged during the major climatic transition around 300,000 years ago, when moisture patterns across Africa were reorganising. The Jebel Irhoud discoveries revealed that early *Homo sapiens* was not confined to a single region but was present across Africa during this important climatic period. The shift in vegetation patterns, with eastern Africa gaining relative abundance and diversity of vegetative resources after 300,000 years ago, may have created new selective pressures that contributed to the emergence of our species. Archaeological evidence shows these early humans were using advanced Middle Stone Age technology, including prepared core techniques and sophisticated hunting strategies. The environmental changes around this time likely facilitated population mixing and cultural exchange across the continent, contributing to the complex evolutionary processes that led to modern humans.

2.7 200,000–70,000 years ago (Middle Stone Age innovation and behavioural modernity)

During this period, African populations developed increasingly sophisticated technologies and symbolic behaviours that mark the emergence of behavioural modernity. At Blombos Cave in South Africa, evidence of ochre processing workshops, engraved designs, and marine shell beads dating to ~100,000-70,000 years ago provides clear evidence of symbolic behaviour. The 73,000-year-old drawing from Blombos Cave represents some of the earliest known graphic designs created by humans. These developments occurred against a backdrop of continued climatic variability, with populations adapting to changing environmental conditions through technological and social innovations. The long tradition of symbolic behaviour spanning over 30,000 years at sites like Blombos Cave and Diepkloof Rock Shelter suggests that these behaviours evolved adaptively, becoming better suited for human perception, cognition, and cultural transmission.

2.8 ~74,000 years ago (Toba eruption and population dynamics)

The massive Toba super-volcanic eruption in Indonesia created a global environmental crisis that may have significantly impacted human populations. While early theories suggested this event caused a severe population bottleneck in Africa, more recent research indicates that humans in some regions, particularly coastal South Africa, not only survived but thrived during this period. Archaeological evidence from Pinnacle Point and other South African coastal sites shows continued human occupation and sophisticated technological traditions through the Toba event. The coastal resources, particularly shellfish, were less susceptible to the volcanic winter effects than inland plant and animal resources, providing crucial refugia for human populations. However, genetic evidence suggests that population dynamics during this period were complex, with some populations experiencing stress while others remained stable.

2.9 ~70,000–50,000 years ago (Late Pleistocene dispersals and cultural complexity)

This period saw both the culmination of symbolic behaviour in Africa and the beginning of major human dispersals out of the continent. The sophisticated cultural traditions evident in the archaeological record—including the refined ochre engravings and shell bead technologies—demonstrate that African populations had developed complex symbolic systems. These cultural innovations likely played important roles in enabling successful dispersals to other continents. Climate conditions during this period, following the Toba event and during Marine Isotope Stage 4 (a cold period from 70,000-60,000 years ago), created both challenges and opportunities for human populations. The end of this cold period coincided with genetic evidence for population expansions and the beginning of successful colonisation of other continents.

ℹ Food crops: 200,000–50,000 years ago (Middle Stone Age)

The focus during this period is on the emergence of early *Homo sapiens* and the development of behavioural modernity. Reader highlights a move towards more sophisticated hunting strategies. Archaeological evidence from coastal South Africa, particularly sites like Pinnacle Point, shows that human populations relied heavily on coastal resources, especially shellfish, as a staple food source. He notes that these resources were less susceptible to the effects of the Toba volcanic winter, providing a vital refugium. The resilience of these populations demonstrates a high degree of adaptability and an understanding of diverse ecosystems, combining hunting and gathering with a reliable marine food source.

2.10 15,000–5,000 years ago (African Humid Period and cultural transformation)

The African Humid Period represents one of the most dramatic environmental transformations in Africa's recent history. Around 14,700 years ago, changes in Earth's orbital parameters brought monsoon rains deep into northern Africa, transforming the Sahara into a green savanna ecosystem. This period, lasting until about 5,500 years ago, supported vast networks of lakes, rivers, and grasslands where today only desert exists. Lake Mega-Chad covered an estimated 350,000 km² at its largest extent. The environmental transformation enabled widespread human settlement across regions that are now uninhabitable.

Archaeological evidence reveals complex hunter-gatherer societies that developed sophisticated technologies and possibly domesticated cattle in some regions. At Nabta Playa in southern Egypt, Neolithic cultures flourished with advanced astronomical monuments and evidence of cattle management between 11,000-5,000 years ago. However, recent analysis suggests that early claims of independent cattle domestication in the Sahara may need revision, with evidence pointing toward introduction from the Middle East around 6,300 years ago rather than local domestication. The rock art of this period, found throughout the now-arid Sahara, depicts a rich fauna including elephants, hippos, crocodiles, and giraffes, providing vivid testimony to the dramatic environmental changes.

ℹ Food crops: 15,000–5,000 years ago (African Humid Period)

The African Humid Period saw a dramatic transformation of the Sahara into a green savanna. This allowed for widespread human settlement across regions that are now desert. The mode of living for people in this period was a transition from hunter-gatherer societies to more complex cultures that may have engaged in early forms of cattle management. While Reader revises earlier claims of independent cattle domestication, it notes that Neolithic cultures at sites like Nabta Playa flourished and had access to a wide range of fauna depicted in rock art, including elephants, hippos, and giraffes. The availability of abundant wild game and water sources likely supported the growth of these complex societies.

2.11 6,000–4,000 years ago (End of the Humid Period and population migrations)

The end of the African Humid Period was not uniform across the continent but occurred in phases from north to south. The transition began around 6,000 years ago and accelerated around 5,500 years ago, with the most severe desiccation occurring around 4,000 years ago. In Egypt, the aridification of the Sahara between 5,000-4,000 years ago created massive environmental stress that likely drove populations toward permanent water sources. The drying was not gradual but occurred in relatively rapid phases over a few hundred years. As grasslands and lakes disappeared, desertification processes accelerated: vegetation loss reduced rainfall generation, light-colored land reflected rather than absorbed sunlight, and soil lost its moisture retention capacity.

This environmental crisis forced large-scale human migrations toward the Nile Valley, fundamentally reshaping the demographic landscape of northeastern Africa. The concentration of populations in the Nile Valley during this period provided the social and economic foundation for the emergence of complex Egyptian civilisation. By 2,000 BCE, the Sahara had become as dry as it is today, with the last major lake drying up around 1,000 BCE. Some researchers suggest these climate refugees from the drying Sahara contributed significantly to the cultural and genetic foundation of ancient Egyptian civilisation.

2.12 5,000–3,000 years ago (Early agricultural expansion and technological transitions)

As the Sahara became increasingly arid, African societies across the continent were developing and expanding agricultural systems based on indigenous crops adapted to local conditions. In West Africa, the domestication of key crops occurred in response to changing environmental conditions. Pearl millet was domesticated around 4,500 years ago in the region that is now northern Mali and Mauritania, probably as lakes created by the earlier humid period began to disappear. African rice was domesticated in northern Mali, while yams were domesticated in the Niger River Basin between eastern Ghana and western Nigeria. In the Sahel region, sorghum was domesticated by 3,000 BCE in Sudan.

These agricultural developments were closely tied to climatic changes. As the climate dried and lake networks vanished around 6,000 years ago, local populations began cultivating plants as wild food sources became less reliable. The genetic analysis of these crops shows that domestication was often a gradual process involving continued interbreeding between wild and cultivated varieties, which slowed full domestication but added crucial genetic diversity. This agricultural expansion provided the foundation for population growth and the development of more complex societies across sub-Saharan Africa.

Food crops: 6,000–3,000 years ago (End of Humid Period and Agricultural Expansion)

This period sees the dramatic shift toward indigenous agriculture. Reader states that as the Sahara became increasingly arid, populations were forced to develop agricultural systems based on locally adapted crops. This led to the domestication of:

- **Pearl Millet (*Cenchrus americanus*)**:
  - Domesticated around 4,500 years ago in northern Mali and Mauritania. Pearl millet is one of the most drought-tolerant cereals in the world. As a C4 grass, it has high photosynthetic efficiency and requires minimal water. It can produce a significant grain yield with as little as 250 mm of annual precipitation and has an extensive root system to access water deep in the soil. It is also highly tolerant of high temperatures, with optimum growth temperatures of 33-35°C and the ability to withstand temperatures up to 42°C. This tolerance to heat and aridity is a key adaptation.
  - The domestication of pearl millet allowed people to remain in and expand into the increasingly arid regions of the Sahel after the end of the African Humid Period. Instead of being forced to migrate to river valleys, communities could establish permanent settlements in semi-arid zones. This agricultural stability provided a foundation for population growth and the development of more complex societies, as labour could be invested in activities beyond daily foraging.
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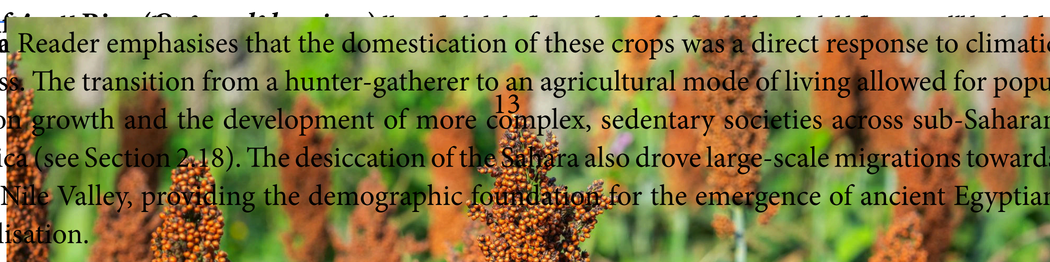
Figure 1: Figure 1: Pearl Millet (*Cenchrus americanus*)[1].



Reader emphasises that the domestication of these crops was a direct response to climatic stress. The transition from a hunter-gatherer to an agricultural mode of living allowed for population growth and the development of more complex, sedentary societies across sub-Saharan Africa (see Section 2.18). The desiccation of the Sahara also drove large-scale migrations towards the Nile Valley, providing the demographic foundation for the emergence of ancient Egyptian civilisation.

2.13 3,000–2,000 years ago (Bantu expansion and Iron Age beginnings)

The expansion of Bantu-speaking peoples from West-Central Africa represents one of the most significant demographic and cultural transformations in African history. Beginning around 5,000 years ago but accelerating around 3,000 years ago, this expansion was closely tied to environmental changes and technological innovations. Climate change around 4,000 years ago created savanna corridors through the Congo rainforest, particularly the Sangha River Interval, which facilitated north-south movement of both people and species.

The Bantu expansion demonstrates how human societies adapted to and took advantage of environmental changes. Savanna-dwelling Bantu speakers showed a clear preference for familiar habitats as they moved southeastward, and their migration was significantly slowed when they encountered rainforest environments—with transitions into rainforest delayed by approximately 300 years compared to movements within savanna habitats. This expansion brought agriculture, livestock herding, and eventually iron-working technology to much of eastern and southern Africa.

The Nok culture in central Nigeria (1500-200 BCE) provides important insights into early Iron Age developments. Contrary to earlier assumptions, the Nok culture began around 1500 BCE as a Neolithic society, with iron technology and elaborate terracotta sculptures appearing only around 900-500 BCE. This demonstrates that complex cultural traditions could develop independently of metallurgy, with iron technology being adopted later to enhance existing social and economic systems.

> **i Food crops: 3,000–2,000 years ago (Bantu Expansion and Iron Age)**
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> The Bantu expansion was driven by a combination of technological innovation and environmental change. Reader notes that Bantu-speaking peoples brought agriculture and livestock herding to much of eastern and southern Africa. Their success was tied to their ability to cultivate crops like sorghum and millet and herd cattle, allowing them to support larger populations and settle new territories. Their expansion was facilitated by the creation of savanna corridors through the Congo rainforest due to climate change, demonstrating how environmental conditions enabled rather than hindered their movements.

2.14 2,000–1,000 years ago (Complex societies and climate adaptation)

During this period, various African societies developed sophisticated strategies for managing environmental variability and building complex political systems. The rise of Great Zimbabwe (founded around 1000 CE) exemplifies how African societies adapted to challenging climatic conditions through innovative technologies. Located in a climate-sensitive region prone to drought, Great Zimbabwe developed an extensive water management system using "dhaka" pits—large depressions that collected and stored both surface and groundwater. This system could store an estimated

[1] Source: A.S. Rao/ICRISAT, https://www.cgiar.org/innovations/high-iron-pearl-millet-for-better-health/

[2] Source: REUTERS/Temilade Adelaja.

[3] Source: Cambridge University Botanic Garden, https://www.botanic.cam.ac.uk/learning/trails/dyestrail/sorghumbicolor/

18,000 cubic meters of water, enabling the city to support 10,000-18,000 inhabitants in a semi-arid environment.

The Medieval Warm Period (c. 900-1300 CE) created favourable conditions for several African polities. In West Africa, the Mali Empire flourished during this time, leveraging trans-Saharan trade routes that benefited from relatively stable climatic conditions. The empire's wealth, famously displayed during Mansa Musa's pilgrimage to Mecca in 1324-1325, was built on controlling gold-producing regions and managing trade networks that connected sub-Saharan Africa with Mediterranean and Middle Eastern markets. These trade routes were possible because the Sahara, while still a desert, was more manageable for caravan travel during the Medieval Warm Period than during subsequent cooler periods.

> **i** Food crops: 2,000–1,000 years ago (Complex Societies)
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> Reader mentions the rise of complex societies like Great Zimbabwe, which developed innovative water management systems to support its large population in a semi-arid environment. This indicates that while agriculture and herding were the primary modes of living, advanced engineering was required to manage the environmental constraints of a climate-sensitive region.

2.15 1300–1850 CE (Little Ice Age impacts and societal responses)

The Little Ice Age brought significant challenges to African societies through altered precipitation patterns and temperature changes. In southern Africa, the abandonment of Mapungubwe around 1290 CE and the simultaneous rise of Great Zimbabwe coincided with the beginning of drier conditions associated with the Little Ice Age. Temperature decreased by about 1°C across much of the continent. The impacts were particularly severe in equatorial East Africa, where widespread drought and desiccation occurred from the late 1700s to about 1830.

Lake systems across the continent experienced dramatic changes: Lake Naivasha was reduced to a puddle, Lake Chad was desiccated, Lake Malawi became so low that people could traverse dry land where deep water normally existed, and Lake Rukwa completely dried up. These drought events were "more severe than any recorded drought of the twentieth century". In West Africa, particularly the Sahel, the Little Ice Age was characterised by a progressive drying trend between 1250 and 1850 CE, with major drought events punctuating the period, the most severe occurring around 1600 CE.

The climatic stresses of the Little Ice Age forced African societies to develop new adaptive strategies. Some communities shifted their settlement patterns, moving to areas with more reliable water sources. Others diversified their economic activities, combining pastoralism, agriculture, and trade to reduce vulnerability to environmental shocks. The end of the Little Ice Age around 1850 CE brought relief to some regions, but also contributed to population growth and increased competition for resources, setting the stage for the social upheavals of the late 19th century.

> **i Food crops: 1300–1850 CE (Little Ice Age)**
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> The Little Ice Age brought significant challenges to African societies through altered precipitation patterns and widespread droughts. The text notes that communities adapted by diversifying their economic activities, combining pastoralism, agriculture, and trade to reduce vulnerability. This period highlights the importance of maintaining multiple livelihood strategies—a theme the text returns to in its conclusion—as a way to build resilience against climate shocks.

2.16 1850–1960 CE (Colonial period and imposed economic transformation)

The Industrial Revolution in Europe and North America was intimately connected to African resource extraction. Coal powered British imperial expansion, while African colonies supplied raw materials to European factories. This extraction-based economic model made African territories more vulnerable to climate shocks by reducing economic diversification and eliminating traditional adaptive strategies.

2.17 1960–2025 CE (Independence, development challenges, and modern climate change)

The post-independence period has been marked by efforts to rebuild African economies while confronting accelerating climate change. Recent data show the average rate of warming in Africa was +0.3°C per decade during 1991-2022, compared to +0.2°C per decade between 1961-1990.

In South Africa, temperatures have increased by 1.5°C since the 1960s, twice the global average warming rate. Rainfall patterns have become more erratic, with hot and cold extremes increasing. Climate models project continued warming throughout the 21st century, with low mitigation scenarios leading to warming well in excess of 3°C posing much higher risks than high mitigation futures limiting warming below 2°C.

Despite these challenges, recent research reveals that African societies have maintained remarkable adaptive capacity. A continent-wide study of livelihood strategies over the past 10,000 years shows that successful adaptation has consistently involved diversifying economic activities rather than relying on single strategies. Communities that combined herding, farming, fishing, and foraging showed greater resilience to climate variability than those focused on intensive single-sector approaches. These historical lessons are increasingly relevant as Africa faces unprecedented climate challenges while building modern economies.

2.18 Food crops and their role in social and political responses for African societies

The agricultural developments discussed, particularly the domestication of drought-tolerant crops, had extensive social and political consequences for African societies. The shift from foraging to farming fundamentally reshaped human social organisation and lead to the rise of food surpluses, the establishment of social hierarchies, and the development of more complex and stratified societies.

Food surplus and sedentism

The transition from a nomadic, hunter-gatherer lifestyle to a sedentary, agricultural one was driven by the **reliability of new food sources**. Crops like sorghum and pearl millet, which can be stored for long periods, allowed communities to accumulate a food surplus. This surplus provided a buffer against environmental shocks, such as drought, and enabled populations to grow. With a stable food supply, people no longer had to constantly move in search of sustenance, leading to the establishment of **permanent settlements**. This shift to sedentism created a new dynamic where communities could invest in more durable infrastructure, such as granaries for storage or, in the case of Great Zimbabwe, complex water management systems.

Specialisation and social stratification

A stable food supply meant that not everyone had to be involved in food production. This allowed for **labour specialisation**. Some individuals could become full-time potters, blacksmiths, or weavers, while others focused on activities like leadership or ritual. This specialisation gave rise to social hierarchies. Leaders emerged who managed the distribution of the food surplus, organised labour for large-scale projects, and controlled trade networks. The Nok culture in Nigeria, with its elaborate terracotta sculptures , is a prime example of a society where complex cultural traditions and specialised craftsmanship developed before the widespread adoption of iron technology.

Population growth and expansion

The combination of a reliable food source and sedentism led to significant **population growth**. Larger populations required more sophisticated political structures to manage conflicts and organise communities. The Bantu expansion, discussed in the text, is a great illustration of this. The Bantu-speaking peoples, armed with agricultural knowledge and later, iron technology, were able to expand across the continent, replacing or integrating with existing hunter-gatherer populations. Their agricultural lifestyle allowed them to support higher population densities, giving them a distinct advantage.

2.19 Contemporary lessons from deep-time adaptation

African history reveals that successful climate adaptation has consistently involved flexibility, diversity, and innovation rather than rigid adherence to single strategies. From the earliest hominins navigating Miocene climate transitions to modern communities facing 21st-century warming, the key to survival has been maintaining multiple livelihood options and strong social networks for sharing resources and knowledge. The archaeological and isotopic evidence shows that communities mixing pastoralism, cultivation, hunting-gathering, and fishing were making context-specific choices that enhanced their resilience to unpredictable conditions.

This deep-time perspective challenges modern development approaches that often privilege intensive agriculture or single-sector economic growth. Instead, Africa's 10,000-year history of climate adaptation suggests that maintaining diverse, flexible livelihood systems—combined with strong social networks and adaptive institutions—provides the most robust foundation for weathering environmental uncertainty. As Africa continues to lead global population growth while contributing minimally to historical greenhouse gas emissions (only 3.8% of global emissions despite hosting 17% of world population), these historical lessons offer valuable guidance for building climate-resilient societies in an uncertain future.

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