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Earth, Water, Air, and Fire – Thinking about Farming and Farmscapes

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Abstract Farming has changed the face of the earth in Africa as much as elsewhere. But histories of African farmscapes, shaped by millennia of agriculture, are obscured by narratives of pristine landscapes, whether of forests or savanna, and the role of farming in transforming African farmscapes is seldom taught in schools. We present examples of farming strategies and systems from western and southern Africa, which we hope are inspiring and maybe, at times, even surprising. Our exploration of the farmscapes, structured along the classical elements of Earth, Fire, Water, and Air, describes how plants and people deal with the influence these elements have on successful farming and how these influences show up in farmscapes. We hope these stories of flexibility, adaptation, and success and failure motivate teachers and students to think out of the box in grappling with the challenges our world is facing. These stories also provide opportunities for teaching about the United Nations Sustainable Development Goals (SDGs), particularly the goals of *Zero Hunger* (SDG 2), *Responsible Consumption and Production* (SDG 12), and *Life on Land* (SDG 15).

Résumé L'agriculture a changé la face de la terre en Afrique comme ailleurs. Mais l'histoire des paysages agricoles africains, façonnés par des millénaires d'agriculture, est obscurcie par des récits de paysages vierges, qu'il s'agisse de forêts ou de savanes, et le rôle de l'agriculture dans la transformation des paysages agricoles africains est rarement enseigné dans les écoles. Nous présentons des exemples de stratégies et de systèmes agricoles d'Afrique occidentale et australe, que nous espérons inspirants et parfois même surprenants. Notre exploration des paysages agricoles, structurés selon les éléments classiques que sont la terre, le feu, l'eau et l'air, décrit comment les plantes et les hommes gèrent l'influence de ces éléments sur la réussite de l'agriculture et comment ces influences se manifestent dans les paysages agricoles. Nous espérons que ces histoires de flexibilité, d'adaptation et parfois d'échec motiveront les enseignants et les étudiants à sortir des sentiers battus pour relever les défis auxquels notre monde est actuellement confronté, et qu'elles pourront être utilisées pour enseigner les objectifs de développement durable (ODD) des Nations unies, en particulier les objectifs "Faim zéro" (ODD 2), "Consommation et production responsables" (ODD 12) et "La vie sur terre" (ODD 15).

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Introduction

Farming has had a profound impact on landscapes in Africa, transforming landforms as well as vegetation. People created terraces to allow farming on hillsides, and much of western African savannas consist of useful trees, furthered by farmers carefully selecting which trees to fell and which to protect. This reality, that farmers altered large parts of sub-Saharan Africa for several millennia, stands in stark contrast to how many people in the Global North imagine Africa – untouched by past human impact. But like on other continents, people in Africa have developed food securing and food production strategies adapted to various environments and social preferences. The resulting farmscapes – landscapes shaped by food production – are as diverse as the land-use strategies that African farmers developed.

In this article, we hope to inspire teachers and students to think and learn about these farmscapes and their diversity. Our spotlights are on western and southern Africa because we, the authors, know more about these regions. Readers can find the location of sites we mention in Figs. 2 and 4 that accompany the introduction to this volume. Similar stories are present everywhere on the continent. We encourage teachers and learners to find and explore other examples to broaden their understanding of indigenous African farming systems and reflect on how these relate to the United Nations (2015) Sustainable Development Goals (SDGs), particularly the goals of *Zero Hunger* (SDG 2), *Responsible Consumption and Production* (SDG 12), and *Life on Land* (SDG 15). A list of additional resources is provided at the end of this paper. We also hope to inspire learners to write their own creative pieces or to delve into online resources, such as Seignobos (2017) and Living Land (n.d.) on historical and contemporary farming in Africa, and write an essay about a subject we have touched on. Each section of the paper starts with a poem, followed by a "thinking-shape" image of African landscapes and farmscapes. Each image offers a set of questions for in-class discussion in the online supplemental resources (OSM 1). We suggest that instructors use the questions to guide students to ponder their perceptions before engaging with our narratives.

Our first "thinking shape" (Fig. 1) shows a hilly landscape covered by savanna vegetation. It is a landscape altered by people, as the farms in the front indicate. Humans created these farmscapes. But living elements in the landscape depend on abiotic factors, literally non-living parts of the environment, like

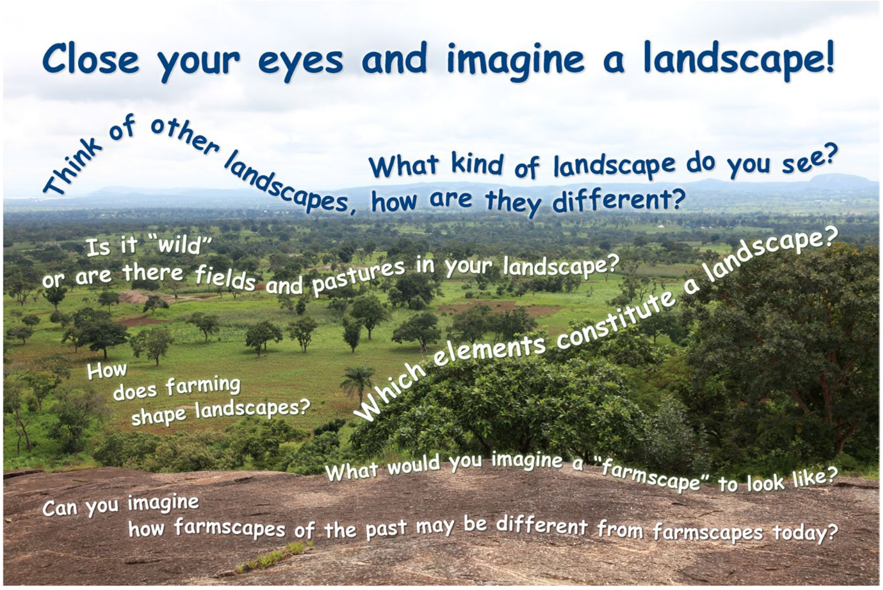

Fig. 1 Landscape thinking-shapes wrapped over a western African farmscape. Photo by Alexa Höhn

Fig. 2 Earth thinking-shapes entwined with a Bokoni terraced farmscape in South Africa. Photo by Alex Schoeman

climate and geology. When we view non-living factors more tangibly, we arrive at the four classical elements, which will navigate us through the remainder of this contribution: Earth nourishes all plant life, and animals burrow and build with and in it. Fire consumes life but prepares the earth for a new life as well. Water is essential for plants and animals, but it also sculpts the earth, incises rivers, and washes down mountains. Moving air — wind — transports plant parts, seeds, and pollen; wind systems form the patterns of wet and dry seasons that are decisive for the success or failure of farming.

Earth, fire, water, and air have agency of their own and are often personified in indigenous African narratives and songs, which we use to frame each section of our paper. The poems and songs highlight indigenous African understandings of the four elements. We explore this relationship between farmers and the four elements through archaeological examples of making African farms and farmscapes in the past, treating each element in turn.

Our research interests shape our contributions to this article. Alexa Höhn bases her research in western Africa and studies charred plant remains. Accidentally burned foodstuffs tell about foraging and farming, and wood charcoal fragments from ancient hearth fires help us to learn about vegetation and vegetation change. Based on the current state of the art, the western African narrative for each element highlights one specific tree and how its presence in past and present farmscapes is related to the elements. In the southern African narrative, Alex Schoeman revisits the work of several generations of archaeologists and palynologists (scientists who study plant pollens), including her team's multi-proxy research on Bokoni farmscapes. The narrative for each element is structured to highlight how farming systems changed and adapted while simultaneously stressing continuities in farmers' strategies. This data bounces off the pedagogical knowledge of Emmanuel Mushayikwa, an education specialist who researches the integration of science and indigenous knowledge systems in the classroom.

Earth

> Oh! Mother Earth, how good you are, how fascinating your appearance
> You're fabricated with delicate and adorable matter, so wonderful that no one passes without standing by and take a glance at you
> Copiously made of life, you supply all Inhabitants of your great terrain life
> Gracious with your resources, you allow everyone to tap from your endless blessings.
> — 'Mother Earth' by J. N. Oyem (2016)

Oyem's (2016) poem encourages us to think about the totality of Earth's blessings, but let us begin by considering those that flow from the substance of

Earth itself (Fig. 2). Soils influence which plants grow in a landscape and for how long they thrive. Farmers' livelihoods depend on soils to supply the nutrients that help crops grow. But soils differ in the kinds and quality of nutrients (e.g., nitrogen, calcium, phosphorous, and potassium) they contain. Today, farmers may rely on commercial fertilizers to benefit their crops by adding nutrients to the soil, but what about in the past?

A common way of dealing with the depletion of nutrients after several cycles of crop cultivation is to allow land to lay fallow. During fallow periods, fields are left to themselves, allowing the soil to regenerate. Traditional land-use systems include the presence of useful trees among the crops. Trees provide fruits, leaves, bark, fibers, plant saps, wood for nourishment, spices, medicines, furniture or tools, and timber. Certain trees provide leaf fodder to animals during the dry season when grass is not available. Such trees are spared when preparing a field. Only those trees not regarded as useful or ones that shade the crops too much are felled, but their stumps remain in the ground. Tending the fields with hoes allows working around them. When fields are abandoned, the useful trees are joined by quick regrowth of shrubs, which either sprout from the stumps of cut trees or seeds in the soil. In older fallows, the fast-growing pioneers of young fallows are replaced by other tree species. The result is farmscapes dotted with trees and consisting of a mosaic of fields and fallows of different ages, which differ in species composition (Fig. 1).

The deep history of these farmscapes is still under investigation, but several regions of western Africa deliver archaeological evidence that allows us to glimpse possible trajectories. Among the trees that are important in tracing fallow rotation in the past is *Guiera senegalensis*. This small tree can deal with repeated cuttings and thrives even on poorer soils. The increase of wood charcoal from this species in archaeological soils points to farmscapes with larger areas of short fallows. One such example comes from northern Burkina Faso. Settlement mounds at the Mare d'Oursi (see Fig. 2 in this issue's "Introduction") reveal a change in farmscapes connected to intensified land use between the end of the first and the beginning of the second millennium CE (Common Era). *Guiera senegalensis* increases in the charcoal spectra dating shortly before and after 1000 CE. We find similar evidence from about the same time in Mali: At Sadia, a study of charcoals from a cluster of settlement mounds shows a similar increase.

At times when people intensified land use by shortening fallow periods, they had to find other ways to replenish soil nutrients. At sites around the large water body of Mare d'Oursi in Burkina Faso, archaeologists found an increase in cattle bones and carbonized seeds, indicative of intensified grazing. This pattern hinted at the use of cattle manure as an additional source of nitrogen. Chemical analysis of carbonized pearl millet grains (*Cenchrus americanus*), the main crop cultivated around the settlements, revealed that grains from later periods had taken up more nitrogen than grains harvested centuries earlier. It appears likely that larger herds, possibly attracted by waters of the Mare d'Oursi, fed on the crop remains in the fields, and their manure ensured sufficient harvests even after shorter fallow periods.

Ensuring sufficient harvests by maintaining soil fertility was also at the core of the development of southern African farming systems. In the first millennium CE, when farming was still new to the region, farmers preferred farming in river valleys, where crops would have thrived in the nutrient-rich alluvial soils. Clearing land for farming through cutting down and burning vegetation supplemented existing soil nutrients. Once settled, farmers might have added additional nutrients by burning the remaining stalks of the crops from the previous season. Evidence for this burning was found in the presence of clay casts of sorghum stalks (*Sorghum bicolor*) at Ndondondwane (see Fig. 4 in the "Introduction"). These casts formed when termites carried soil up the stalks of plants—when the dried stalks burned, these casts were baked. The success of these methods is visible in the continuous occupation of sites, such as KwaGandaganda and Ntshekane in eastern South Africa, over hundreds of years. Such stable, long-term habitation suggests that farmers successfully managed soil fertility and avoided land degradation (SDG 15.3) within their preferred farmscapes.

Shifting systems required access to sufficient fertile land, and this resource came under increasing pressure in the second millennium CE when southern Africa's population grew and the towns of Mapungubwe and Great Zimbabwe developed (Fig. 4 in this volume's "Introduction"). Initially, farmers chose extensification — expanding the amount of land under cultivation to increase the amount of food produced. But by the sixteenth century, some farmers in Nyanga, Zimbabwe, and Bokoni, South Africa, changed their relationship with the earth and started to reshape it by building terraces (see Fig. 2 above). Terraces allowed them to expand their farming from the river valleys onto steep slopes, where soils tend to be shallow, and farming otherwise would lead to erosion. In Bokoni, where clay soils were very dense, terrace building also helped to aerate the clay soils. This facilitated root development because the small gaps formed when moving earth during terrace construction make it easier for oxygen, water, and nutrients to get into the soil where the roots can access them.

Bokoni's terraces were wrapped around homesteads in densely occupied towns. Here, space for farming was at a premium, and fallowing was less viable. Consequently, they managed soil fertility differently. By placing terraces around people's homesteads, nutrients could leach into the soils from the livestock enclosures in the homesteads. The proximity also made manuring easier, and the possibility of the practice is suggested by the absence of manure buildup in the livestock enclosures. The women who farmed these terraces further managed the problem of tired fields and a new problem that came from living in a dense town — rubbish disposal. Instead of throwing their rubbish onto ash heaps or into pits, as people had done in southern Africa for more than a millennium, the women in Bokoni towns disposed of household rubbish and domestic fire ash on the terraces. This increased the level of nutrients in the terrace soils and further broke up the clay soils by adding organic matter. This practice makes Bokoni one of Africa's few pre-colonial farming community sites that do not have rubbish heaps. In terms of responsible consumption (SDG 12), what can we learn from this practice?

Inspired by Oyem's (2016) poem, we explored how African farmers managed the earth to ensure it contains enough nutrients for crops to grow. Can you think of other examples of farmers working for sustainable life on land (SDG 15)?

If you would like to learn more about the examples from western Africa, you could read Höhn and Neumann (2012) on the developments at the Mare d'Oursi, Huysecom et al. (2015) for Sadia, and Roll (2022) on contemporary uses of *Guiera senegalensis*. The chemical analyses of pearl millet and their implications are published in Styring et al. (2019). For more about the spatial distribution of first-millennium farming and pastoralism in southern Africa, you could turn to Lander and Russell (2018). By reading Greenfield et al. (2005) you could find out more about sorghum stalk casts. Whitelaw (1994) contains an example of long-term and repeated site use. Soper (2006), Delius et al. (2012), and Widgren et al. (2016) will help you gain a foothold in terrace farming in Nyanga and Bokoni. Winowiecki and Park (2021) contains accessible information on the importance of soil health to farming.

Fire

Who has started the fire
Someone has started the fire in the field
Climb up the watch tower and call to the people at home
Someone has started a fire
Come and see the fields are burning
Climb up the watch tower and call to the people at home
In Zimbabwe, the above song is accompanied by drums, mbira (thumb piano), and marimba (a variety of xylophone)
—Traditional Shona song 'Ndianiko apisa moto' performed by Nyami Nyami Sounds (2008)

The ability to make fire is symbolic of being human, but, more than all the other elements, fire can only be harnessed, never tamed. The song cites the dangers of fire and its destructive force (Fig. 3). But by consuming the dried biomass of savanna grasses, fire also makes room for new plant growth. In the form of ashes, nutrients from plant matter are quickly returned to the ground. Many plants in fire-prone environments even show adaptations to fire. Small pyrophytes (literally "fire plants") resprout from underground organs after their above-ground biomass has been destroyed. Others survive the fire season as seeds in the ground. Some pyrophytes even produce fruits that need contact with fire to release the seeds. Trees in such environments often have thick bark that protects the delicate tissues necessary for growth and nutrient transport in the stem.

In western Africa, the shea tree, scientifically *Vitellaria paradoxa*, is such a tree adapted to dry season fires. It is one of the most useful trees of semi-arid savannas, which burn regularly during the dry season. Today, it is present in farmscapes from the Gambia

Fig. 3 Fire thinking-shapes speaking to a veld fire in South Africa. Photo by Alex Schoeman

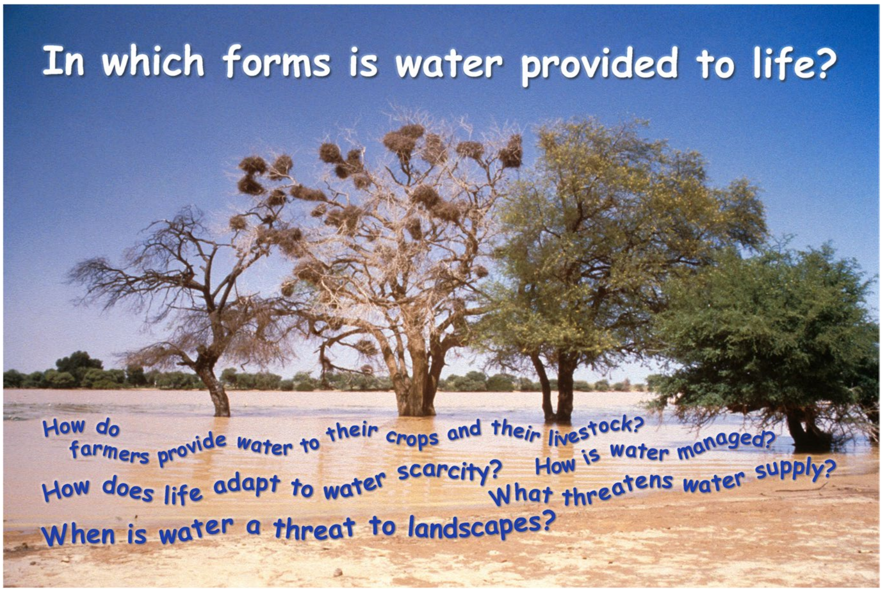

Fig. 4 Water thinking-shapes lapping the shores of a temporary lake in northern Burkina Faso. The trees are adapted to temporary flooding. Photo by Alexa Höhn

River to Uganda, not so much because of its resistance toward fire damage, but because of its fruit. The fruit pulp is edible, but the resource that distinguishes shea from many other useful trees of African savannas is the oil contained within the seed. It is processed into shea butter, used in cooking and for skin and hair care. Shea is not domesticated, but neither are its existing populations natural. Ibn Battuta, an explorer from northern Africa who traveled to western Africa in the middle of the fourteenth century, already noted the dominance of shea trees around settlements. But how much more ancient might such farmscapes dominated by shea be?

Archaeologists find evidence of shea exploitation in the form of carbonized seed shells and wood charcoal. The oldest finds come from northern Burkina Faso and date to at least 3000 years ago, but people could have harvested fruits and wood from wild trees. To trace the active management and propagation of shea trees in farmscapes, we need evidence such as an increase in the amount of shea wood charcoal at a site over time. We find this at Kirikongo, a site in Burkina Faso (Fig. 2 in the "Introduction"). Its inhabitants produced shea butter. They built ovens for parching and left behind huge amounts of seed shells. They also used shea wood to build their houses and as fuel. At the heyday of the settlement in the twelfth to fourteenth century CE, more than 50% of the fuel wood at the site belongs to this species. At Sadia, similar evidence for the development of shea farmscapes is present. Archaeologists found shea wood charcoal in similar frequencies by the eighth to tenth century CE. In the Dendi region of northern Benin, shea wood charcoal reaches frequencies above 50% at a site dating after the sixteenth century. In contrast, in earlier contexts, the frequencies are three times lower. While we need data from more sites to be sure, it seems likely that early shea parks formed somewhere within central western Africa and then slowly spread into other regions.

We do not yet know if cultivated tree parks developed in southern Africa. However, the increase in the pollen of the fire-sensitive marula (*Sclerocarya birrea*) tree in the Tswaing Crater in northern South Africa early in the second millennium CE, while other forest and savanna tree elements decreased, is tantalizingly suggestive. Marula pips have been found in several excavations in northern South Africa and Zimbabwe, and these trees are still an important resource in these regions. From oral and historical sources, we know that farmers also have a long history of looking after other fruit, medicinal, functional, and symbolic trees. When they cleared bush for new fields, these trees were not burnt, nor were they used for firewood in a manner that would harm the tree population. Many of these trees are fire-sensitive and only grow in areas where they are protected from the annual veld fires.

In contrast, grassland and fynbos biomes evolved into fire-dependent landscapes over millennia. But, in the last 100 years, modern farming and fire control regimes have slowly transformed the grassland and fynbos biomes by *preventing* annual fires. These new fire regimes allowed fire-sensitive trees to become more abundant but with effects on general biodiversity (SDG 15). This is not the first time we have seen changes in fire regimes driven by people's actions cause vegetation change in southern Africa. Around 200 to 300 CE, an extension of open savanna in northeastern South Africa and vegetation changes in the fynbos biome on the Cape Flats probably signaled the arrival of livestock and crop farmers moving onto these landscapes. Archaeologists know that the vegetation changed because the pollen and phytoliths (mineral particles that form in plants) found in wetland soil cores show a decrease in trees and an increase in grasses. At the same time, larger charcoal particles in cores from these areas increased, which indicates an increase in the number and/or extent of fires. This change in the fire regime reflects new activities on the landscapes. On a landscape scale, the livestock farmers deliberately set wildfires at the end of the dry season to remove dying vegetation and allow new grass — preferred by livestock — to grow. On a more localized scale, these farmers used fire to help clear trees and shrubs to create the fields we discussed in the "Earth" section. They also used fire to make the metal tools with which they felled the trees and worked the earth.

The Zimbabwean fire song at the start of this section reminds us that wildfires spread easily and may be dangerous to farming. But we also discussed how plants have adapted to fires and farmers have used fire for millennia. Which SDGs do you think are impacted by wildfires?

You can learn more about the shea tree with Maranz and Wiesman (2003) and by watching GBios Laboratory's (n.d.) YouTube video, and read about Kirikongo in Gallagher et al. (2016). Several publications contain charcoal records of shea, among them Neumann et al. (1998) and Eichhorn (2018). To gain insight into the relationship between vegetation change, climate, and farming in South Africa during the last 2000 years, you could read Olatoyan et al.'s (2022) review of published work. Metwally (2011) and Neumann et al. (2011) report on the palynological analyses of cores from the Tswaing Crater and Cape Flats, while Mutshinyalo and Tshisevhe (2003) discuss marula trees.

Water

Come down sweet rain;
Come rain on me
Like you rain on the tree,
The maize and the grass;
And they grow and grow and grow.
—'Rain' by Sam Mbure (1992)

As stated in the poem by Sam Mbure (1992), rain is necessary for maize and other crops to grow. But water is distributed unevenly on the African continent. Timing and length of rains vary, from erratic rains over a few days of the year to a few weeks or several months with rainfall. Rainfall also varies from year to year, and water management is crucial. Different strategies are used. Some opted for technical solutions like irrigation, while others used adaptive solutions such as planting together varieties of crops with varying water (rainfall) needs. Rivers and lakes also provide water, some permanently, others only seasonally, with water levels changing drastically due to annual rainfall in their catchments. Adjacent low-lying areas may be flooded for weeks or months (Fig. 4). While exceptional floods at the wrong time are devastating to farming, regular and recurrent floods are often beneficial. They enrich the floodplains with nutrients transported in soil particles taken from upstream areas. The best-known example of successful adaptation to annual floods in Africa is ancient Egypt, but, as we discuss below, it is not the only one.

Some trees have adapted to regular flooding and do not mind "getting their feet wet," as you can see in Fig. 4. A tree whose name refers to a habitat close to water is the Nile acacia, *Vachellia nilotica*. It does not only grow along the Nile but also close to water bodies in other regions of Africa, one of which is in the Chad basin. Here, a massive lake — Lake Mega Chad — developed during a wetter period ca. 14,500 to 5000 years ago (Fig. 2 in this volume's "Introduction"). From about 4000 years ago, people took advantage of its receding shores as conditions became drier. In the clay plains of the former lake bed, people procured and produced foods in systems adapted to a seasonal flood regime. The last region they occupied was the *firgi* clay plains. Here, the trajectory of farmscapes started about 3000 years ago, with cattle herding and small-scale cultivation of pearl millet. Based on what archaeobotanists see elsewhere (like Kirikongo), we would expect to see evidence of farmscapes with useful trees and fallow species in the charcoal assemblages. Instead, woody species that do not mind getting their feet wet tell the tree-side story of these farmscapes.

Three thousand years ago, soon after the clay plains were exposed to drying conditions, people with cattle exploited the plains for fodder and food seasonally as the annual flood waters receded. They set up camp on small sand islands elevated above the plains. Here, they grazed their cattle and foraged for wild grasses and water lily seeds. The impact of the annual floods was still strong; fuelwood for fires was mostly collected from shrubs that could endure long-term flooding. But some hundred years later, in the second half of the first century BCE, fuelwood composition changed. The Nile acacia (*Vachellia nilotica*), a tree that copes well with lower and shorter flooding, became more prominent and points to decreased flood duration and height. People still exploited water-related wild resources, like fish, wild rice, water lilies, and wild grasses, but the importance of pearl millet farming increased. After 500 CE, the charcoal spectrum indicates a further lowering of flood levels. Further evidence suggests a diversified land-use system, including the cultivation of sorghum and cotton, but the wood charcoal evidence does not indicate the presence of farmscapes with useful trees and fallow species. Two factors may be at play. First, pearl millet may have been cultivated on larger sand islands, where larger surfaces allowed shifting cultivation but where archaeological excavations have yet to take place. Second, when people started to turn the rangeland of the clay plains into fields for cultivating sorghum, they possibly cleared all the trees. Shifting cultivation is not necessary when annual floods replenish the nutrient content of the soils. And treeless farmscapes have the advantage that grain-feeding birds that potentially reduce the harvests do not find nesting opportunities.

Grain-feeding birds are a particular problem for African crops such as pearl millet, finger millet (*Eleusine coracana*), and sorghum, which have small seeds. Yet, these crops were cultivated for over two millennia in southern Africa. The earliest evidence for the presence of millet includes an early first-millennium pearl millet seed impression in pottery from Silver Leaves in South Africa and finger millet seeds from Kadzi in Zimbabwe (see the location of these sites in Fig. 4 of the "Introduction"). In the "Earth" section, we discussed the mid-first millennium CE sorghum stalk casts. During this same period, sorghum seeds were found in several excavations across southern Africa, from Mondake in Zambia, the Chowo River on the border between Zambia and Malawi, the Shashe-Limpopo Confluence Area in northern South Africa and southern Zimbabwe, to Bokoni in South Africa. Large-scale sorghum cultivation continued into the 1800s, and the British missionary Reverend Campbell described large sorghum fields at the Tswana town, Kaditshwene, in northwestern South Africa.

We suggest that farmers favored millet and sorghum because their cultivation helped to enhance food security (SDG 2). These African staple crops have relatively deep root systems that allow these plants to grow in areas with lower rainfall levels and tolerate droughts. Some millets can grow in places with as little as 350 mm per year! This ability to grow with little moisture is important because most southern African farming is rain-fed.

In southern Africa, there is one notable exception to the pervasive practice of dryland farming: the floodplain farmers of the Shashe-Limpopo Confluence Area (SCLA). Its valleys are sandy and challenging to farm because sand is relatively nutrient poor and dries out quickly. To make things even more difficult for farmers, the area has very low rainfall levels ranging between 350 and 500 mm per annum. But, like many other African farmers, the SLCA farmers were innovative and adapted their farming techniques to fit the conditions. Instead of only planting on dryland and waiting for the rain, as was the case elsewhere in southern Africa in the first millennium CE, these farmers started cultivating in the Limpopo River floodplain during the 900s CE. This allowed them to take advantage of the increased moisture available to crops and introduced additional nutrients into the soil. These farmers were so successful that, by the 1200s, they were able to produce enough food for the estimated 5000 people who lived in the largest SLCA town, Mapungubwe. The rain that Sam Mbure (1992) poetically invoked does not always fall when needed. Regardless of the weather, farmers all over Africa found ways to work with the water systems to grow food in sufficient quantities (SDG 2).

The information on the developments at Lake Chad is summarized in Höhn et al. (2020). You can learn more about some of the southern African sites where crops were found in Olatoyan et al. (2022). Sorghum was an important crop in both regions, and to find out more about it you could read Nzouankeu (2014) and Rampho and Reynolds (2005). Reading Smith et al. (2007) will teach you more about rainfall and farming innovations in the SLCA.

Air/Wind

From the west
Clouds come hurrying with the wind
Turning sharply
Here and there
Like a plague of locusts
Whirling,
Tossing up things on its tail
Like a madman chasing nothing
—"An African Thunderstorm" by David Rubadiri (2004)

As the poem states, wind may bring clouds; winds prevailing for a longer period shape seasons (Fig. 5). Those loaded with humidity from the oceans bring wet seasons, and the wind inside the continent brings dry seasons. Wind and wind systems determine seasonality, and thus growth season, so they are important for farming. The dry season, especially in regions marginal for agriculture due to lower rainfall levels, was a time of scarcity for which farmers needed to develop coping strategies. Farming in marginal zones is even more challenging through fluctuations in rainfall driven by large-scale meteorological forcing. Recurring years or even decades of drought in various parts of (semi-)arid Africa stress farming strategies. These usually resulted in population movement into neighboring regions that have higher precipitation.

In western Africa, the harmattan is the dry-season wind. A southwestward wind out of the Sahara transports dust into the Sahel and adjoining savannas. Plant life comes to a halt, but one tree is in full leaf, despite the dry wind: the applethorn (*Faidherbia albida*, syn. *Acacia albida*). It pushes its leaves when other plants are seemingly dead. This is a blessing to livestock; when all grass has dried up, the leaves and the protein-rich pods of the applethorn are important feeds, bridging the time of scarcity until the next wet season. The transition begins when the monsoon, a trade wind from the Atlantic, gains force and penetrates inland over western Africa. Heavy with humidity, it brings much-needed rains after several months of drought. When the savanna re-greens, the applethorn sheds its leaves. Farmscapes are then dotted with gray applethorn skeletons like the one seen in Fig. 5. Having been a blessing to livestock herders during the dry season; farmers now benefit from its presence. It does not cast shade while crops are growing, and its fallen leaves, high in nitrogen content, serve as fertilizer. The tree's reversed phenology (its reversed seasonal timing) of being in leaf during the dry season speaks against western Africa as the

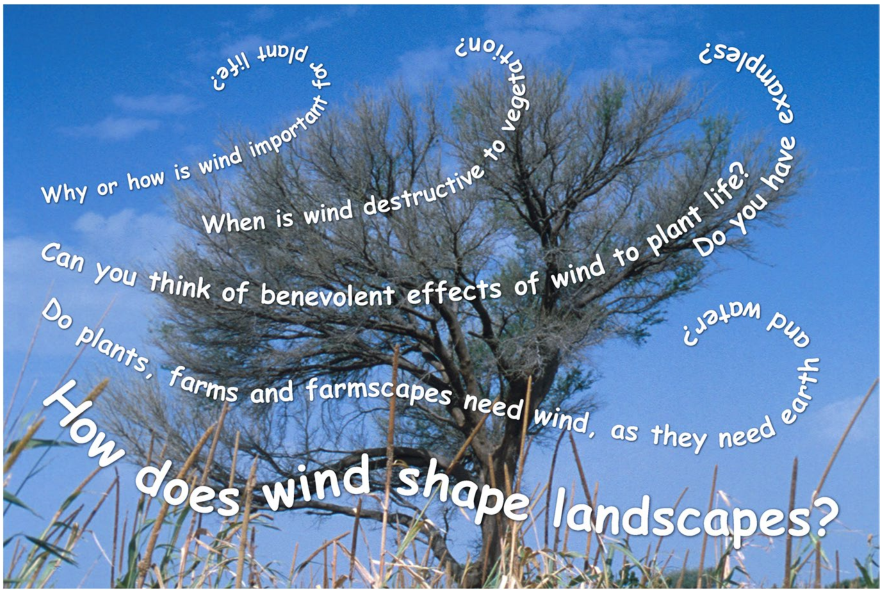

Fig. 5 Wind thinking-shapes blowing over an applethorn tree and a pearl millet field in northern Burkina Faso. Photo by Alexa Höhn

natural habitat of the tree. Its presence is often attributed to the advance of specialized nomads during the last millennium. But from where?

So far, the earliest evidence of the applethorn in western Africa comes from Fachi, an oasis in eastern Niger, where one wood charcoal fragment has been identified in a soil layer about 7000 years old. The oldest piece found in a settlement is about 2500 years old and was identified from a site in the Chad Basin. Only much later, around 1000 CE, do we find evidence of farmscapes with applethorn, with numbers of fragments appearing more steadily in the sites. We see this first in the western part of central western Africa and only several centuries later to the southeast in northern Cameroon. The wood charcoal evidence for applethorn parks is not as robust as that for shea parks, and larger datasets are needed to corroborate that such parks emerged in connection with the advancement of specialized pastoralists with larger herds of cattle. Unlike shea, present in natural savannas and which multiplies in farmscapes, applethorn possibly could have been an introduction into at least parts of the region. If so, it is a latecomer introduced into the savanna farmscapes of western Africa, but before trees like mango, teak, and neem arrived through colonial networks.

Colonialism and the politics associated with it did much more than add trees and crops to the farmscapes of Africa. In the "Water" section, we described how southern African farming systems and crops were adapted to rainfall fluctuations. Their ability to cope can be severely tested when prolonged droughts stretch over several decades, and their resilience systems can fail when larger-scale political processes impact local strategies. In South Africa, a prolonged drought that stretched from the later eighteenth into the early nineteenth century acted in combination with several other sociopolitical factors, including colonial expansion, which forced African farmers into more marginal regions.

To complicate matters, the Baobab carbon isotope record, which allows climate specialists to track past rainfall changes, indicates that the drought followed decades of higher rainfall. During these times, farmers relaxed their drought resilience strategies and started to farm more marginal fields and cultivate less drought-resistant crops like maize. As the drought progressed, elements combined to worsen conditions. Wind and warmer temperatures evaporated water, adding to the water deficit and negatively affecting crop yields. The resulting crop failures posed challenges to food security in large parts of the eastern half of South Africa. In several regions, this caused famine.

In areas where competition between expanding African polities was already intense, this food insecurity resulted in inter-community violence, which caused the scattering of refugees and large-scale migrations. Oral traditions recall the rippling destruction associated with the political conflict and migrations from eastern South Africa. The processes mentioned in these traditions took different material forms in the many early nineteenth-century refugia built across eastern South Africa. These places of refuge included an entire settlement built in an underground cave, stonewalled villages moving into steep ravines with few points of access, and royal homesteads moving onto the top of steep-sided hills. Simultaneously, the large terraced Bokoni towns we discussed earlier were abandoned. This placed additional stress on food security in affected areas. These ripples of distress were eventually felt throughout southern Africa as migrants fleeing the troubles in South Africa took refuge in countries such as Mozambique, Zimbabwe, Malawi, and Zambia. This disaster underscores how the elements and political variables affect food security (SDG 2).

At times African farmers' resilience strategies failed when the winds dispersed rather than brought clouds for long periods. However, the sustainability of African indigenous farming methods has made it possible for African farmers to survive through diverse periods of climate change. Despite changes in farming practices brought about by the commercialization of agriculture during colonial and post-colonial eras, traditional African farming practices have endured and evolved, becoming more pronounced during periods of prolonged droughts and economic upheaval. An example is the contemporary resurgence of "zero tillage" for growing small grains, rice, and maize on the Zimbabwean plateau. Zero tillage is less labor intensive, does not require access to expensive farming equipment, and aids soil conservation because crops are planted without disturbing the soil through plowing or tilling.

You can learn more about the applethorn tree in Wickens (1969) and Dembele (n.d.) and the significance of its charcoal presence in Höhn and Neumann (2012). To find out more about the impact the prolonged drought at the end of the 1700s and early 1800s had on farming communities, you could read Hall (1976) and Schoeman et al. (2019), and watch the clip by Klingenboeck and Silva (2020) to understand how researchers gained some of this knowledge.

Conclusion

The examples we discussed in this article only provide glimpses of how African farmers have been collaborating, negotiating, and battling with the four elements for millennia. Some farming created diversity, while some remodeled entire landscapes, as in the terracing at Bokoni. Most of these strategies were sustainable. Farmers managed their farms by relying on diverse crops combined with the exploitation of wild and managed resources and having mobile rather than stalled livestock. These traditional forms of sustainable land use, adapted to the particular environment, created diverse and resilient farmscapes. Unlike the monotonous fields or plantations that came to characterize cash-cropping in colonial times, farmers transformed the natural landscape while maintaining aspects of grasslands, savannas, woodlands, and even forests in their farmscapes. As mentioned, archaeology-based knowledge about indigenous land use and traditional farmscapes can contribute to the UN Sustainable Development Goals of *Zero Hunger* (SDG 2), *Responsible Consumption and Production* (SDG 12), and *Life on Land* (SDG 15).

These examples of making farms and farmscapes in African history show a deep knowledge and understanding of the four elements and the living world. They counteract stereotypes of a primitive Africa in historical times. With adaptability and innovation at the core of these farming systems, they demonstrate that indigenous knowledge systems can teach us about sustainable land use, which creates and maintains a richness of exploitable plant products from farmscapes and beyond. With their diversity in taxa and ecological niches, these systems are more resilient than many systems of land use termed modern and efficient, but which are not adapted to the elements of Africa's diverse environments.

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