A Multi-Millennial Climate History of Afrin, Syria: From the Pleistocene to the Anthropocene Threshold (2010)

Introduction

The Afrin District (Kurdish: *Herêma Efrînê*), known historically as the Kurd-Dagh or "Mountain of the Kurds," occupies a unique and critical space in the landscape of human history and climate.[1] Situated in the northwestern corner of Syria's Aleppo Governorate, the region is defined by the fertile valley of the Afrin River, which flows from the Taurus Mountains, bisects the district, and carves a path through its hilly, mountainous terrain before re-entering Turkey.[4] This geography places Afrin at a climatic and ecological crossroads, a verdant bridge between the humid coast of the Mediterranean Sea to the west and the vast, arid steppes of the Syrian interior to the east.[6] As a core component of the Fertile Crescent, this region was a cradle of the Neolithic Revolution, witnessing the profound transition from nomadic foraging to settled agriculture that would reshape the course of civilization.[4]

Central to the identity, economy, and ecological story of Afrin is the olive tree (*Olea europaea*).[4] More than just a crop, the olive is a cultural keystone and a living bio-indicator of the region's long-term climatic patterns. Archaeological and historical evidence suggests that intensive olive cultivation has been a feature of this landscape for at least 4,000 to 6,000 years, a testament to a climate uniquely suited to its needs.[9] The enduring presence of these ancient groves provides a tangible link between the deep past and the present, their cycles of prosperity and decline mirroring the climatic fluctuations that have defined the region for millennia.

This report aims to construct an exhaustive, multi-millennial climate history of the Afrin region, from the transformative environmental shifts of the Late Pleistocene to the instrumentally recorded modern era, culminating at the 2010 threshold of a new, more volatile period. Given the absence of direct, long-term paleoclimatic archives from Afrin itself, this analysis employs a multi-proxy approach, synthesizing data from the broader Northern Levant. This includes high-resolution pollen records from locations such as the Ghab Valley in northwestern Syria, which reveal past vegetation changes; sediment cores from the Dead Sea and Lake Van, which act as powerful indicators of regional hydroclimate and drought cycles; and isotopic data from speleothems (cave formations), which provide detailed information on past rainfall and environmental conditions.[12] By integrating these scientific archives with archaeological findings and historical accounts, this report will trace the intricate and often dramatic interplay between climate, environment, and human society in Afrin. The narrative will proceed chronologically, beginning with an analysis of the modern climate to establish a baseline, then moving backward through the historical periods of the Ottoman Empire, the Middle Ages, and Classical Antiquity, before delving into the deep Holocene past to uncover the climatic foundations upon which Afrin's unique agricultural landscape was first built.

Part I: The Modern Climate and its Recent Historical Context (c. 1900-2010)

To comprehend the scale and impact of past climatic shifts, it is essential first to establish a detailed baseline of the region's modern climate. This section characterizes the contemporary climate of Afrin up to 2010 using instrumental data and the Köppen classification system. It then examines the significant warming and drying trends of the 20th century, culminating in the severe drought of 2006-2010, an event that serves as a critical modern analogue for understanding the societal consequences of climate stress.

Characterizing the Contemporary Climate (up to 2010)

The climate of Afrin is definitively classified under the Köppen system as **Csa**, or a **hot-summer Mediterranean climate**.[16] This classification is not merely a label but a precise description of a climatic regime that has profoundly shaped the region's ecology, agricultural potential, and rhythm of life for millennia. The Csa type is defined by a distinct set of characteristics: temperate, mild, and wet winters where the coldest month's average temperature remains above freezing (0°C); hot and dry summers, with at least one month's average temperature exceeding 22°C; and a pronounced seasonal precipitation pattern, with the vast majority of rainfall occurring during the winter months.[19] This cycle of winter moisture and summer drought is the defining feature of the Mediterranean biome and dictates the success of its native flora, most notably the drought-resistant olive and grape cultivars that are central to Afrin's economy.[6]

While specific, long-term meteorological records for Afrin city are limited, data from the major nearby city of Aleppo provides a robust and widely used proxy for the region's general climatic conditions.[22] Analysis of this data up to 2010 paints a clear picture of the Csa climate in practice.

- **Temperature:** Summers in the region are described as "sweltering, dry, and clear".[22] The hot season typically lasts for nearly four months, from early June to late September, with average daily high temperatures consistently above 31°C (89°F).[25] July is the hottest month, with average highs reaching 36°C (97°F) and average lows around 24°C (75°F).[22] Conversely, the cool season lasts from late November to early March. Winters are cool and partly cloudy, with January being the coldest month, featuring average high temperatures of around 10°C (50-52°F) and average lows near 2-3°C (36-37°F).[16] Snowfall is occasional but not uncommon in the winter months.[16]

- **Precipitation:** The region's precipitation regime displays the dramatic seasonality characteristic of a Mediterranean climate. The wet season spans from mid-October to late April, during which there is a significant chance of rainfall.[25] Precipitation peaks in the winter months of December, January, and February, with each month receiving an average of 50-65 mm (2.0-2.5 inches) of rain.[22] The period from late May through September constitutes a prolonged dry season, with the summer months of June, July, and August being virtually rainless, often receiving less than 2 mm of precipitation combined.[22] This pattern means that all traditional, rain-fed agriculture must be adapted to survive the intense summer drought.
- **Cloud Cover and Sunshine:** The seasonal patterns of temperature and precipitation are mirrored by cloud cover. The clearer part of the year begins in mid-May and lasts for nearly five months, with July and August being almost perfectly clear on average.[22] This maximizes solar radiation during the hottest part of the year. The cloudier part of the year aligns with the wet season, from October to May, with January being the cloudiest month, where the sky is overcast or mostly cloudy nearly half the time.[25]

The following table, compiled from proxy data for Aleppo, provides a quantitative summary of the average climatic conditions for the region in the late 20th and early 21st centuries, establishing a crucial baseline for historical comparison.

Table 1: Average Monthly Climate Data for Aleppo (Proxy for Afrin), c. 1980-2010

Month	Avg. High Temp (°C)	Avg. Low Temp (°C)	Avg. Monthly Rainfall (mm)	Avg. Rainy Days
January	10	2	64	8
February	12	3	52	8
March	17	6	46	7
April	23	10	34	5
May	29	15	18	3
June	34	19	3	1
July	36	23	1	<1
August	36	22	1	<1
September	32	19	3	1
October	26	14	27	4
November	18	7	36	6
December	12	4	57	8

Data compiled and averaged from sources.[22] Note: "Rainy Days" defined as days with at least 1 mm (0.04 inches) of precipitation. Values are rounded for clarity.

The 20th Century Warming and Drying Trend

The climate of the 20th century was not static. Instrumental records for Syria reveal a clear and persistent trend toward warmer and drier conditions, a pattern that accelerated toward the end of the century.[26] By 2010, the country was, on average, approximately 0.8°C hotter than it was a century earlier.[26] This long-term trend, driven by anthropogenic global warming, began to significantly alter the baseline conditions, increasing the frequency and intensity of extreme weather events. While the overall trajectory was toward aridification, it was also marked by increased variability, including occasional seasons of extreme rainfall and flooding.[26] The most consequential manifestation of this trend in the period leading up to 2010 was the severe, multi-year drought that gripped the entire Fertile Crescent.

The drought from the winter of 2006-2007 through 2010 was the most severe in the region's instrumental record.[27] This was not merely a random, albeit extreme, natural event. Scientific analysis demonstrates that the long-term, human-forced drying trend made a drought of this intensity two to three times more likely than it would have been under natural conditions alone.[26] This event thus represents a critical historical inflection point: a hybrid catastrophe where natural climate variability was dangerously amplified by a century of anthropogenic warming, creating a crisis that exceeded the coping capacity of the society and its government.

The impact of this drought was catastrophic, particularly for Syria's agricultural sector. The country's "breadbasket" in the northeast, which historically produced over two-thirds of its crops, collapsed.[27] Wheat production failed, forcing Syria to become a major importer of grain for the first time in decades, and the agricultural sector's contribution to the national GDP plummeted.[27] This agricultural collapse was compounded by decades of unsustainable state policies that had created profound underlying vulnerabilities. Aggressive government-led projects had encouraged the unsustainable exploitation of groundwater for irrigation, leading to a dramatic drop in the water table and the complete drying up of vital tributaries like the Khabur River.[26] When the rains failed for multiple years, the groundwater reserves that might have served as a buffer in past droughts were already depleted, leaving farmers with no recourse.[26]

The socio-economic consequences were devastating and far-reaching. The collapse of the rural economy triggered a massive internal migration, with as many as 1.5 million people—mostly farming families and herders who had lost their entire livelihoods—fleeing the desiccated countryside for the peripheries of Syria's major cities.[27] These urban centers were already strained by rapid population growth and a large influx of refugees from the war in Iraq.[28] The arrival of these internally displaced "climate refugees" created vast, impoverished shantytowns, placing immense pressure on scarce resources like water, housing, and employment, and fostering the conditions of desperation and discontent that would contribute to the outbreak of widespread civil unrest in 2011.[27] The 2006-2010 drought, therefore, serves as a powerful modern illustration of how climate change acts as a "threat multiplier." The event itself did not single-handedly cause the subsequent crisis, but it interacted with and catastrophically exacerbated pre-existing vulnerabilities created by poor governance and unsustainable environmental management, ultimately pushing a stressed society past its breaking point.

Part II: Historical Climate Fluctuations and Societal Impact (c. 1500-1900)

Moving back from the instrumentally recorded era, this section examines the climate of the Ottoman period. By using paleoclimatic proxies like tree rings and historical records, it is possible to reconstruct the significant climatic variability of this era and analyze its profound impact on the agrarian society of the Ottoman Levant, including the region of Afrin. This period was notably shaped by the global climatic downturn known as the Little Ice Age, which manifested in the Eastern Mediterranean not just as cooling, but as a period of intense and disruptive aridity.

Climate of the Ottoman Era

The Little Ice Age (LIA), a period of global climatic cooling and instability lasting roughly from the 16th to the mid-19th century, had a distinct and severe expression in the Ottoman Empire.[30] While often characterized by glacier advances in Europe, its impact in Anatolia and Syria was primarily felt through its effect on precipitation. High-resolution pollen records from Syria and extensive tree-ring data from Anatolia converge to show that the LIA was significantly cooler and, more critically for this semi-arid region, substantially drier than both the preceding Medieval Climate Anomaly and the modern climate.[30] The Ottoman heartland, which had expanded from the temperate Balkans into the arid zones of the Middle East, was thus faced with a formidable environmental challenge.[21]

This period was not one of uniform dryness but was punctuated by episodes of extreme, multi-year drought that were among the most severe in the last millennium. Paleoclimatological reconstructions have identified the two decades surrounding the year 1600 as particularly harsh, experiencing some of the coldest and driest conditions in the region's recorded history.[30] Tree-ring chronologies pinpoint an exceptionally prolonged and severe drought lasting from 1591 to 1595, the longest such dry spell in a 600-year record.[32] These extreme climatic events were not isolated incidents but part of a larger pattern of instability that included frequent frosts and floods, which further destabilized agricultural production.[30]

The severe climatic stress of the LIA acted as a powerful catalyst for some of the most significant crises of the Ottoman era. The timing of the most extreme droughts aligns remarkably with periods of widespread social and political upheaval. The devastating droughts of the late 16th and early 17th centuries, for instance, coincided directly with the Celâlî Rebellions, a series of revolts that convulsed the Anatolian countryside.[32] The link was not coincidental but causal. The prolonged poor harvests and resulting famines, directly attributable to the climatic downturn, created widespread desperation among the rural populace. This environmental crisis was fatally compounded by the actions of the state. The Ottoman government, engaged in costly wars in Europe, continued its policies of oppressive taxation and requisitioning grain and meat from the already starving peasantry.[30] This combination of environmental shock and institutional pressure exposed the critical failings of the Ottoman provisioning system, turning a natural hazard into a full-blown societal catastrophe and fueling the flames of rebellion.[30]

The consequences of this convergence of climate stress and political failure were dire and long-lasting. Historical sources describe a landscape ravaged by famine, disease, and bloodshed.[30] Faced with starvation and violence, vast numbers of people abandoned their farms and villages, fleeing the Anatolian and Syrian countryside in search of safety and sustenance. This led to a massive wave of depopulation, leaving large swathes of formerly productive agricultural land deserted. The demographic and economic impact was so profound that some regions did not recover to their pre-crisis population levels for centuries.[30] This pattern of climate-induced hardship persisted through the Ottoman period. The great famine of the 1870s, for example, has also been linked to a combination of severe drought and exceptionally cold, snowy winters, which once again imposed unequal and devastating hardships on the population, demonstrating the recurring vulnerability of the region's agrarian society to climatic extremes.[34] The history of the Ottoman period in the Levant is thus inseparable from its climate. The LIA was not merely a background condition but an active agent of change, repeatedly testing the resilience of the empire's institutions and its people, and demonstrating how the combination of climatic stress and poor governance can lead to cycles of crisis and collapse.

Part III: Climate of Antiquity and the Early Middle Ages (c. 500 BCE - 1500 CE)

This part delves further into the past, exploring the major climatic epochs that coincided with the rise and fall of the great civilizations that controlled the Levant, from the Roman Empire to the early Islamic Caliphates. This long span of history witnessed dramatic swings in climate, from the stable optimum that supported Roman prosperity to periods of severe turmoil that profoundly reshaped the region's agricultural capacity and influenced the course of history.

The Roman and Early Byzantine Climate Optimum (c. 200 BCE - 400 CE)

The establishment and consolidation of Roman rule in the Near East coincided with a period of remarkable climatic stability known as the Roman Warm Period (RWP).[35] Lasting for several centuries, this era was characterized by relatively warm, stable, and likely wetter conditions across much of the Mediterranean basin. This climatic optimum was a crucial enabling factor for the unprecedented prosperity and demographic expansion of the Roman Empire, and its effects were particularly pronounced in the fertile provinces of the Levant.[35]

During this period, Roman Syria, which encompassed the Afrin region, flourished as a vital agricultural and economic hub.[8] The region's productivity was so legendary that the fertile Houran plain in the south became known as the "granary of Rome," supplying essential grain to the heart of the empire.[38] This agricultural abundance supported a demographic peak that was not to be seen again until the 19th century, with the population of the Levant estimated to be between 3.5 and 6 million people.[8] Great urban centers like Antioch (near modern Antakya, just across the border from Afrin) and Palmyra reached populations of up to 250,000, sustained by the surplus generated from the intensively cultivated hinterlands.[8]

The foundation of this prosperity was the quintessential Mediterranean agricultural triad: grains, grapes, and olives.[36] The favorable and reliable climate of the RWP was ideal for the expansion of these crops. Olive cultivation, in particular, saw a massive expansion. Archaeological evidence from the limestone hills of northwestern Syria—the very region that includes Afrin—reveals a boom in the construction of sophisticated olive and grape presses during Late Antiquity (roughly 4th-6th centuries CE).[39] Villages like Déhès saw the construction of dozens of new presses employing advanced screw-weight technology, indicating a highly organized, large-scale, and profitable industry.[39] The presence of significant Roman-era ruins in the Afrin district itself, including well-built bridges and the tomb complex at Nebi Huri (ancient Cyrrhus), attests to the region's wealth and its full integration into this thriving imperial economic system.[2] This era represents the apex of agricultural development in the ancient Levant, underwritten by a climate that was both benevolent and predictable.

Climatic Turmoil and Transition (c. 400 - 1200 CE)

The stability of the Roman Warm Period did not last. The transition from Late Antiquity to the Early Middle Ages was marked by two distinct and severe climatic downturns that fundamentally reshaped the environmental and political landscape of the Levant. These events acted as a "one-two punch," delivering shocks that stressed civilizations to their limits and contributed to the broad historical realignments of the period.

The first major shock was the **Late Antique Little Ice Age (LALIA)**, an abrupt and severe cooling event that affected the entire Northern Hemisphere from approximately 536 to 660 CE.[41] This climatic downturn was not a gradual change but a rapid onset event, triggered by a series of massive volcanic eruptions between 536 and 547 CE that ejected vast quantities of sun-blocking aerosols into the atmosphere, leading to a "volcanic winter".[41] The impact on the

Byzantine Empire, the successor to Rome in the East, was profound. This period of dramatic cooling coincided almost exactly with the outbreak of the devastating Plague of Justinian, which began in 541 CE.[42] While a direct causal link between cooling and plague is debated, the climatic stress, which would have disrupted agriculture and weakened populations through malnutrition, almost certainly increased societal vulnerability to the pandemic.[42] Archaeological evidence provides a stark picture of the consequences. In the Negev Desert, a marginal arid zone of the empire, studies of ancient trash mounds reveal an abrupt cessation of organized waste disposal and a collapse of the urban and agricultural systems around the mid-6th century, precisely when LALIA began.[43] While core agricultural areas of the Levant may have shown more resilience, the LALIA was a severe environmental shock that contributed to a complex matrix of decline, particularly in the empire's frontier zones, and helped set the stage for the geopolitical shifts to come.[44]

Following a period of relative climatic recovery, the region was struck by a second, and in some ways more severe, climatic crisis during the **Medieval Climate Anomaly (MCA)**, which spanned from roughly 950 to 1300 CE. This period was not monolithic but was characterized by two sharply contrasting hydroclimatic phases in the Levant.[45] The first phase, from approximately 900 to 1100 CE, was a period of intense and prolonged drought. Paleoclimate archives, including critically low water levels in the Dead Sea, salt deposits in sediment cores, and pollen data from Syria indicating arid-adapted vegetation, all point to one of the driest epochs of the last two millennia.[45] This period of extreme aridity, which appears to coincide with a phase of low solar activity known as the Oort Grand Solar Minimum, is well-documented in historical chronicles, which describe widespread famine, pestilence, and conflict across the region as a direct result of the persistent droughts.[45] Around 1100 CE, the climate regime shifted dramatically. The second phase of the MCA, lasting until about 1300 CE, was marked by significantly wetter conditions, which would have allowed for a substantial recovery in the region's agricultural capacity.[45]

The historical narrative of this era—encompassing the decline of Byzantine power in the Levant and the rise of the Islamic Caliphates—cannot be fully understood without this climatic context. The transition was not simply a matter of battles and conquests. It occurred across a landscape whose fundamental carrying capacity was being radically altered by forces beyond human control. The weakening of the Byzantine system during the LALIA, followed by the societal crises spurred by the devastating early MCA droughts, created conditions of instability and opportunity that shaped the political and social transformations of the Early Middle Ages. The continuity of agrarian life noted by some scholars must be seen not as a sign of climatic irrelevance, but as a testament to the remarkable resilience of Levantine societies in the face of immense environmental challenges.[44]

Part IV: Paleoclimate of Afrin and the Origins of its Agricultural Landscape

To understand the full arc of Afrin's history, it is necessary to look beyond written records and into the deep time of the Holocene epoch, the geological period of the last ~11,700 years. This section utilizes high-resolution paleoclimatic proxy data from the wider region to reconstruct the environmental foundations upon which Afrin's society and its iconic agricultural landscape were first built. This journey into the past reveals that the region's climate has been subject to dramatic shifts that directly enabled, challenged, and reshaped human civilization from its very beginnings.

The Holocene Climate Record: A Foundation for Civilization

The reconstruction of prehistoric climates relies on natural archives that preserve a record of past environmental conditions. For the Northern Levant, including the Afrin region, several key proxies provide a coherent, though geographically broad, picture of long-term climatic change.

- **Pollen Records:** Sediment cores extracted from lakebeds and marshes, most notably from the Ghab Valley in northwestern Syria, contain ancient pollen grains.[14] By analyzing the changing composition of this pollen—for example, a shift from tree pollen like oak (*Quercus*) to the pollen of steppe grasses and shrubs like *Artemisia*—scientists can reconstruct the history of vegetation. Such shifts are powerful indicators of changes in temperature and moisture, revealing periods of forest expansion during wet phases and aridification or anthropogenic deforestation during dry phases.[14]
- **Lake Sediments:** The sediments of terminal lakes like the Dead Sea and Lake Van in eastern Turkey are exceptionally sensitive hydroclimate indicators.[13] During wet periods with high rainfall and river inflow, lake levels rise, and the sediments are characterized by fine layers of detritus and aragonite. During periods of intense drought, lake levels fall dramatically, and thick layers of salt (halite) are deposited as the water evaporates.[13] The continuous, often annually-laminated (varved) records from these lakes provide an unparalleled chronology of regional wet and dry cycles over tens of thousands of years.[15]
- **Speleothems:** The chemical composition of cave formations like stalagmites provides another high-resolution climate proxy.[49] The ratios of stable oxygen and carbon isotopes (δ^{18}O and δ^{13}C)trappedinthelayersofcalcitecanbepreciselydatedandrevealinformationaboutthesourceandamountofpastrainfall(δ^{18}O)andthetypeofvegetationcoverinthelandscapeabovethecave(δ^{13}C), which distinguishes between C3 plants (trees, most shrubs) and C4 plants (many grasses common in arid environments).[12]

These proxies collectively chart the major climatic events of the Holocene. The most critical of these was the transition at the start of the epoch, around 11,700 years BP (Before Present). The end of the preceding Younger Dryas, a period of intense cold and aridity, gave way to an abrupt and dramatic shift to a much warmer and wetter Early Holocene climate.[14] This climatic amelioration was the fundamental enabling condition for the Neolithic Revolution. Pollen records from northwest Syria clearly show the expansion of deciduous oak forests across the landscape at this time, replacing the arid steppe vegetation of the glacial period.[14]

This initial warming and wetting trend progressed toward a **Mid-Holocene Climatic Optimum**, a long period of general stability and moisture. In the Near East, peak humidity and the highest lake levels are recorded between approximately 6200 and 4000 BP.[15] However, this long-term stability was punctuated by abrupt and severe arid events that had profound consequences for nascent civilizations. The most famous of these is the **4.2 ka BP event (c. 2200 BCE)**, a global "megadrought" that is recorded in proxies worldwide and is linked to the collapse of the Akkadian Empire in Mesopotamia and widespread societal crisis across the Near East.[8] Later, another severe dry period is associated with the **Late Bronze Age Collapse (c. 1200 BCE)**, an event marked in pollen records by a dramatic decrease in tree cover, indicating severe drought and the decline of complex societies across the Eastern Mediterranean.[46] The following table provides a master chronology of these major climatic phases and their societal correlations.

Table 2: Major Climatic Periods and Events in the Levant (Late Pleistocene to Present)

Time Period	Approximate Dates	Dominant Climate Characteristic	Key Proxy Evidence	Major Societal Correlation
Younger Dryas	c. 12,900-11,700 BP	Cold, very dry, steppe vegetation	Ghab pollen, Lake Van sediments	Late hunter-gatherer societies (Natufian)
Early Holocene	c. 11,700-8,200 BP	Abrupt warming, significantly wetter	Ghab pollen (oak forest expansion)	**Neolithic Revolution**, origins of agriculture
8.2 ka Event	c. 8,200 BP	Abrupt, sharp cooling and drying	Global records, speleothems	Cultural changes in early Neolithic sites
Mid-Holocene Optimum	c. 8,000-4,500 BP	Warm, humid, stable	Lake Van highstands	Rise of early urban civilizations (Bronze Age)
4.2 ka Event	c. 4,200-3,900 BP	Severe, multi-century "megadrought"	Dead Sea lowstands, Mesopotamian dust	Collapse of Akkadian Empire, Early Bronze Age crisis
Late Bronze Age	c. 3,550-3,150 BP	Relatively wet and stable	Palynological records	Flourishing of palatial economies
Late Bronze Age Collapse	c. 3,200-3,100 BP	Severe, abrupt drought	Pollen records (deforestation)	Collapse of Mycenaean, Hittite, Ugaritic

				civs.
Roman Warm Period	c. 200 BCE - 400 CE	Warm, stable, relatively wet	Historical records, proxies	Roman/Byzantine agricultural & demographic peak
Late Antique Little Ice Age	c. 536-660 CE	Abrupt volcanic cooling, disruption	Tree rings, ice cores, historical records	Justinian Plague, Byzantine decline in marginal areas
Medieval Climate Anomaly	c. 900-1300 CE	Phase 1 (900-1100): Severe drought. Phase 2 (1100-1300): Wet	Dead Sea levels, pollen records	Phase 1: Famine/conflict. Phase 2: Agricultural recovery
Little Ice Age	c. 1550-1850 CE	Cooler and significantly drier	Tree rings, pollen records	Ottoman-era famines and social unrest (Celâlîs)
Modern Warming Trend	c. 1900-2010 CE	Warming (~0.8°C), increasing aridity	Instrumental records	2006-2010 drought, agricultural collapse

Dates are approximate and based on a synthesis of sources.[8]

The Deep History of Agriculture in the Afrin Region

The climatic shifts of the Holocene did not just form a backdrop to human history; they were the very engine of its most fundamental transformation. The warmer, wetter, and more climatically stable conditions of the Early Holocene were the essential permissive factor for the development of agriculture. In northern Syria, this transition is clearly visible in the archaeobotanical record. Sites from this period show a marked shift in plant use, away from the wild rye and floodplain seeds that dominated hunter-gatherer diets during the colder Younger Dryas, and toward the systematic cultivation of new staples: barley, emmer wheat, lentils, and peas.[54] This was not a simple choice but a profound adaptation to a new world of environmental possibility, a move from chasing resources to producing them in one place.[50]
However, the iconic agricultural landscape of Afrin—the land of olives—was the product of a second, later agricultural revolution. The olive tree, a long-lived species requiring a specific Mediterranean climate, was not among the initial suite of Neolithic founder crops.[9] Its widespread cultivation represents a more mature phase of agricultural development, one that required not just favorable conditions but also long-term social and climatic stability. The investment in an olive grove is a multi-generational commitment, as trees grow slowly and only

become fully productive after decades.[9]
Palynological and archaeological evidence from sites in the region, such as Tell Mastuma in the nearby Idlib province, provides a clear timeline for this development. The mass production of olives appears to have begun during the Early Bronze Age (c. 3600-2500 BCE), a period that corresponds to a particularly wet and stable climatic phase in the Levant.[11] This new form of arboriculture brought immense economic prosperity to the region, underpinning the growth of complex, urbanized societies.[11]
This olive-based economy, however, was acutely vulnerable to climatic shifts. The same archaeological record from Tell Mastuma shows that this prosperity was shattered at the end of the Late Bronze Age (c. 1200 BCE), when a severe and prolonged drought devastated the olive groves. The site was catastrophically destroyed and abandoned for over 700 years, a stark testament to the fragility of this specialized agricultural system in the face of major aridification.[11] The site was only reoccupied, and olive cultivation revived, when the climate shifted back to wetter conditions during the subsequent Iron Age.[11] This recurring cycle of climate-driven expansion and collapse of olive cultivation is a microcosm of Afrin's deep history. It reveals that the region's identity as "the land of olives" is not an ancient, unchanging fact, but the result of a specific climatic window that opened in the Bronze Age and has been sustained, with major interruptions, by the region's characteristic Csa Mediterranean climate ever since.[4]

Conclusion: A Synthesis of Climate, History, and Resilience in Afrin

The multi-millennial climatic journey of the Afrin region is a story of profound transformation, resilience, and the intricate, unbreakable bond between human society and its environment. From the post-glacial genesis of a habitable world to the human-amplified challenges of the modern era, the region's climate has been the primary variable shaping the possibilities and limits of life. The paleoclimatic record, read through the proxies of ancient pollen, lake sediments, and cave formations, reveals a history not of stasis, but of dramatic fluctuation. The abrupt warming and wetting at the dawn of the Holocene, some 11,700 years ago, was the pivotal event that unlocked the potential for agriculture, allowing the region's inhabitants to transition from foraging to farming and lay the foundations of civilization.
Subsequent millennia were defined by a rhythm of climatic optima and crises. The stable, humid conditions of the Bronze Age and the Roman Warm Period underwrote eras of unprecedented agricultural productivity, demographic expansion, and urban prosperity. It was during these benevolent windows that Afrin's signature agricultural identity, centered on the capital-intensive and long-term investment of olive cultivation, was forged and flourished. Conversely, periods of severe climatic stress—the megadroughts of the 4.2 ka and Late Bronze Age events, the volcanic winter of the Late Antique Little Ice Age, and the arid phases of the Medieval and Little Ice Ages—repeatedly brought famine, social upheaval, and collapse.

These events were not mere background noise; they were powerful agents of change that toppled empires, triggered mass migrations, and reset the course of history.
Throughout this long history, the fundamental character of Afrin's climate—the Csa, or hot-summer Mediterranean regime—has been both a unique resource and a defining boundary. It enabled a highly specialized and resilient form of agriculture perfectly adapted to its cycle of wet winters and dry summers, which in turn shaped the region's culture and economy for thousands of years. Yet, the inherent variability of this climate, with its recurring, often severe droughts, has perpetually tested the adaptive capacity of its inhabitants and the institutions they built.
Ultimately, the climate history of Afrin reveals a complex, non-deterministic relationship between nature and society. For most of its history, societal success and failure were intimately tied to the ability to navigate and adapt to natural climatic fluctuations. The period ending in 2010, however, marks the dawn of a new and more precarious paradigm. The severe drought of 2006-2010 was not a purely natural disaster but a hybrid catastrophe, where natural variability was amplified by a century of anthropogenic warming and decades of unsustainable state policies. This illustrates a critical shift: human activity has transitioned from being a force that adapts to the environment to a primary driver of its vulnerability. The long and rich history of climate and society in Afrin thus offers a profound lesson, demonstrating that while the climate sets the stage, it is the resilience of social and political structures that ultimately determines whether a society can weather the inevitable storm.

Works Cited

1. mesopotamia.coop. "Afrin." Mesopotamia. Accessed July 8, 2024. [4]
2. Wikipedia. "Afrin District." Last modified June 28, 2024. [1]
3. Wikipedia. "Afrin Region." Last modified June 18, 2024. [2]
4. Tubeileh, Ashraf, et al. "A topography map of northwestern Aleppo Governorate showing Afrin area with the orchard." ResearchGate, 2014. [20]
5. Wikipedia. "Afrin, Syria." Last modified July 3, 2024. [16]
6. WeatherSpark. "Climate and Average Weather Year Round in ‘Afrīn Syria." Accessed July 8, 2024. [25]
7. Mindat.org. "Köppen Climate Classification." Accessed July 8, 2024. [17]
8. Big Ladder Software. "Köppen Climate Classification." Accessed July 8, 2024. [18]
9. WeatherSpark. "Climate and Average Weather Year Round in Aleppo Syria." Accessed July 8, 2024. [22]
10. Met Office. "Aleppo (Syria) weather." Accessed July 8, 2024. [23]
11. Weather2Travel.com. "Aleppo climate." Accessed July 8, 2024. [24]
12. Bar-Matthews, Miryam, et al. "The spectrum of Pleistocene-Holocene climate and vegetation change in the southern Levant (Israel) from speleothem and faunal records." *Quaternary Science Reviews* 287 (2022): 107567. [12]

13. Maher, Lisa A., et al. "A panarchy of social-ecological systems in the southern Levant." *Proceedings of the National Academy of Sciences* 109, no. 15 (2012): 5636-5641. [50]
14. Neugebauer, Ina, et al. "Hydroclimatic variability in the Levant during the early last glacial (~117-75 ka) - a view from the northern Dead Sea." *Climate of the Past* 12, no. 1 (2016): 75-90. [13]
15. Langgut, Dafna, et al. "Vegetation and Climate Changes during the Bronze and Iron Ages (~3600–600 BCE) in the Southern Levant Based on Palynological Records." *Radiocarbon* 58, no. 2 (2016): 325-346. [46]
16. University of Florida. "Speleothem-based climate proxy records Research." Accessed July 8, 2024. [49]
17. Wikipedia. "8.2-kiloyear event." Last modified June 26, 2024. [53]
18. Britannica. "Syria: The winds." Accessed July 8, 2024. [6]
19. Climate Centre. "Syria: Climate-related risks and impacts." Red Cross Red Crescent Climate Centre, 2021. [26]
20. de Châtel, Francesca. "Did Drought Trigger the Crisis in Syria?" *Footnote*, 2014. [29]
21. Duffy, Andrea. "What the Ottoman Empire can teach us about the consequences of climate change – and how drought can uproot peoples and fuel warfare." Colorado State University, 2020. [30]
22. Husain, Faisal. "The Ottoman Arid Frontier: The Social and Environmental History of an Early Modern Empire." Rachel Carson Center for Environment and Society, Ludwig-Maximilians-Universität München, 2017. [33]
23. Inalcik, Halil, and Donald Quataert, eds. *An Economic and Social History of the Ottoman Empire, 1300-1914*. Cambridge University Press, 2009. [21]
24. Kelley, Colin P., et al. "Climate change in the Fertile Crescent and implications of the recent Syrian drought." *Proceedings of the National Academy of Sciences* 112, no. 11 (2015): 3241-3246. [27]
25. White, Sam. "The Seventeenth-Century Crisis and the Ottoman Empire." In *Climate Change and the Middle East: Past, Present and Future*, edited by Johannes Koder and Martin Koechy, 2006. [32]
26. Gratien, Chris. "The Great Famine in the Ottoman East, 1879-81." *Smith College Faculty Publications*, 2020. [34]
27. Wikipedia. "Geography of Syria." Last modified June 28, 2024. [7]
28. Ancient Ports Antiques. "Temperature." Accessed July 8, 2024. [35]
29. The Century Foundation. "Syria's Environmental Crisis Is Its Achilles' Heel." Accessed July 8, 2024. [60]
30. Getty Museum Store. "Roman Syria and the Near East." Accessed July 8, 2024. [37]
31. Syria Direct. "Granary of Rome: Can the Houran's wheat survive climate change and war?" Accessed July 8, 2024. [38]
32. Wikipedia. "Byzantine economy." Last modified June 25, 2025. [61]
33. Fernandez, Sonia. "Prehistoric cosmic airburst preceded the advent of agriculture in the Levant." UC Santa Barbara, 2023. [56]

34. Hadas, Guy, et al. "Decline of a desert frontier: Urban collapse and societal response to the Late Antique Little Ice Age in the Negev Desert." *Proceedings of the National Academy of Sciences* 116, no. 43 (2019): 21469-21474. [43]
35. Ellenblum, Ronnie, et al. "The hydroclimate history of the Eastern Mediterranean during the Medieval Climate Anomaly." *Atmosphere* 10, no. 1 (2019): 29. [45]
36. Haldon, John, et al., eds. *A Companion to the Environmental History of Byzantium*. Brill, 2024. [44]
37. Wikipedia. "History of the ancient Levant." Last modified July 7, 2024. [8]
38. Hammude. "A Tale of Afrin." Youth4Nature, 2021. [59]
39. Syria Direct. "Earthquake and climate change: Afrin River dries, farmers lose out." September 17, 2023. [5]
40. Mesopotamia.coop. "Olives of Afrin exported to other countries by Turkey." Mesopotamia, 2021. [9]
41. Satoyama Initiative. "Syria: Olive cultivation on hilly land in the northwestern part of the country and along its Mediterranean coast." March 6, 2012. [62]
42. Traveling The Unknown. "Afrin, Syria: A Visit to the Land of Olives." 2025. [40]
43. Democratic Kurdish Center of France. "Withering Branch: The Story of Afrin and its People's Pre & Post Operation Olive Branch." March 9, 2022. [10]
44. Kaniewski, David, et al. "The Little Ice Age in Syria: A cool and dry interval." *Méditerranée. Revue géographique des pays méditerranéens* 119 (2012): 55-62. [31]
45. Yasuda, Yoshinori, et al. "The earliest record of major anthropogenic deforestation in the Ghab Valley, northwest Syria: A palynological study." *Quaternary International* 73-74 (2000): 127-136. [14]
46. Willcox, George. "Late Pleistocene and Early Holocene climate and the beginnings of cultivation in northern Syria." *The Holocene* 17, no. 3 (2007): 347-355. [54]
47. Wick, Lucia, et al. "Evidence of Lateglacial and Holocene climatic change and human impact in eastern Anatolia: High-resolution pollen, charcoal, isotopic and geochemical records from the laminated sediments of Lake Van, Turkey." *The Holocene* 13, no. 5 (2003): 665-675. [15]
48. Kempe, Stephan, and Gunnar Landmann. "Climatically induced Lake level changes at Lake Van, Turkey during the Pleistocene/Holocene transition." *Mitteilungen aus dem Geologisch-Paläontologischen Institut der Universität Hamburg* 79 (1996): 1-14. [48]
49. Wikipedia. "Agriculture in ancient Rome." Last modified July 2, 2024. [36]
50. Kaniewski, David, et al. "Middle East coastal ecosystem response to middle-to-late Holocene climate change." *Proceedings of the National Academy of Sciences* 105, no. 37 (2008): 13941-13946. [52]
51. Kaniewski, David, et al. "The 4.2 ka BP event in the Levant." *Climate of the Past* 14, no. 10 (2018): 1529-1546. [51]
52. Nadel, Dani, et al. "The domestication of olive." *Frontiers in Plant Science* 14 (2023): 1131557. [58]
53. Tsuneki, Akira. "The Rise and Fall of Olive Cultivation in Northwestern Syria: A

Palaeoecological Study of Tell Mastuma." *International Research Center for Japanese Studies*, 2009. [11]
54. Lewit, E. "Elaion: Olive Oil Production in Roman and Byzantine Syria-Palestine." In *The Rural Home in the Roman World*, edited by P. Erdkamp and K. Verboven, 2014. [39]
55. Henry, Donald O. "Adaptation and Innovation in the Epipaleolithic of the Levant." *Journal of Anthropological Research* 67, no. 2 (2011): 181-207. [50]
56. Zeder, Melinda A. "The Broad Spectrum Revolution at 40: Resource diversity, intensification, and an alternative to optimal foraging explanations." *Journal of Anthropological Archaeology* 31, no. 3 (2012): 241-264. [55]
57. Büntgen, Ulf, et al. "Cooling and societal change during the Late Antique Little Ice Age from 536 to around 660 AD." *Nature Geoscience* 9, no. 3 (2016): 231-236. [41]
58. Wikipedia. "Late Antique Little Ice Age." Last modified June 28, 2024. [42]
59. Langgut, Dafna, et al. "Ancient Climate Change Transformed Us from Nomadic Hunters to Settled Farmers." Tel Aviv University, November 25, 2021. [57]
60. Foreign Policy in Focus. "The Drought That Fell Assad." December 13, 2024. [28]
61. Wikipedia. "Köppen climate classification." Last modified July 7, 2025. [19]
62. WeatherSpark. "Average Weather in Aleppo, Syria." Accessed July 8, 2024. [22]

Works cited

1. Afrin District - Wikipedia, accessed July 8, 2025, https://en.wikipedia.org/wiki/Afrin_District
2. Afrin Region - Wikipedia, accessed July 8, 2025, https://en.wikipedia.org/wiki/Afrin_Region
3. World Directory of Minorities and Indigenous Peoples - Syria : Kurds - Refworld, accessed July 8, 2025, https://www.refworld.org/country,,,,SYR,,49749ca0c,0.html
4. Afrin (Afrîn / Efrîn) - Co-operation in Mesopotamia, accessed July 8, 2025, https://mesopotamia.coop/cities/afrin/
5. Farmers 'ruined' as earthquake and climate change leave Afrin River dry - Syria Direct, accessed July 8, 2025, https://syriadirect.org/earthquake-and-climate-change-afrin-river-dries-farmers-lose-out/
6. Syria - Climate, Deserts, Winds | Britannica, accessed July 8, 2025, https://www.britannica.com/place/Syria/The-winds
7. Geography of Syria - Wikipedia, accessed July 8, 2025, https://en.wikipedia.org/wiki/Geography_of_Syria
8. History of the ancient Levant - Wikipedia, accessed July 8, 2025, https://en.wikipedia.org/wiki/History_of_the_ancient_Levant
9. Olives of Afrin exported to other countries by Turkey – Co-operation ..., accessed July 8, 2025, https://mesopotamia.coop/olives-of-afrin-exported-to-other-countries-by-turkey/
10. Withering Branch: The Story of Afrin and its Peoples, Pre & Post "Operation Olive

Branch" | Washington Kurdish Institute, accessed July 8, 2025, https://dckurd.org/2022/03/09/withering-branch-the-story-of-afrin-and-its-peoples-pre-post-operation-olive-branch/
11. 251-273 - THE RISE AND FALL OF OLIVE CULTIVATION IN - NORTHWESTERN SYRIA, accessed July 8, 2025, https://nichibun.repo.nii.ac.jp/record/350/files/IJ0817.pdf
12. The last glacial cycle of the southern Levant: Paleoenvironment and chronology of modern humans - PubMed, accessed July 8, 2025, https://pubmed.ncbi.nlm.nih.gov/31142433/
13. Hydroclimatic variability in the Levant during the early last glacial (~117–75 ka) derived from micro-faci - CP, accessed July 8, 2025, https://cp.copernicus.org/articles/12/75/2016/cp-12-75-2016.pdf
14. The earliest record of major anthropogenic deforestation in the Ghab Valley, northwest Syria: A palynological study | Request PDF - ResearchGate, accessed July 8, 2025, https://www.researchgate.net/publication/223515674_The_earliest_record_of_major_anthropogenic_deforestation_in_the_Ghab_Valley_northwest_Syria_A_palynological_study
15. (PDF) Evidence of Lateglacial and Holocene climatic change and human impact in eastern Anatolia: High-resolution pollen, charcoal, isotopic and geochemical records from the laminated sediments of Lake Van, Turkey - ResearchGate, accessed July 8, 2025, https://www.researchgate.net/publication/200033718_Evidence_of_Lateglacial_and_Holocene_climatic_change_and_human_impact_in_eastern_Anatolia_High-resolution_pollen_charcoal_isotopic_and_geochemical_records_from_the_laminated_sediments_of_Lake_Van_Turk
16. Afrin, Syria - Wikipedia, accessed July 8, 2025, https://en.wikipedia.org/wiki/Afrin,_Syria#:~:text=is%20re%2Destablished.-,Climate,in%20January%2C%20February%20or%20December.
17. The Köppen Climate Classification - Mindat, accessed July 8, 2025, https://www.mindat.org/climate.php
18. Köppen Climate Classification: Auxiliary Programs — EnergyPlus 8.9 - Big Ladder Software, accessed July 8, 2025, https://bigladdersoftware.com/epx/docs/8-9/auxiliary-programs/k-ppen-climate-classification.html
19. Köppen climate classification - Wikipedia, accessed July 8, 2025, https://en.wikipedia.org/wiki/K%C3%B6ppen_climate_classification
20. A topography map of northwestern Aleppo Governorate showing Afrin area with the orchard locations (red dots). - ResearchGate, accessed July 8, 2025, https://www.researchgate.net/figure/A-topography-map-of-northwestern-Aleppo-Governorate-showing-Afrin-area-with-the-orchard_fig7_267097004
21. explorations in Ottoman environmental history - The White Horse Press, accessed July 8, 2025, https://www.whpress.co.uk/Books/Inal%20extract.pdf
22. Aleppo Climate, Weather By Month, Average Temperature (Syria ..., accessed July 8, 2025, https://weatherspark.com/y/100214/Average-Weather-in-Aleppo-Syria

23. Aleppo (Syria) weather - Met Office, accessed July 8, 2025, https://weather.metoffice.gov.uk/forecast/sy6myfqgb
24. Aleppo weather by month: monthly climate averages | Syria - Weather2Travel.com, accessed July 8, 2025, https://www.weather2travel.com/syria/aleppo/climate/
25. 'Afrīn Climate, Weather By Month, Average Temperature (Syria) - Weather Spark, accessed July 8, 2025, https://weatherspark.com/y/99838/Average-Weather-in-%E2%80%98Afr%C4%ABn-Syria-Year-Round
26. 1. Country overview - Red Cross Red Crescent Climate Centre, accessed July 8, 2025, https://www.climatecentre.org/wp-content/uploads/RCCC-ICRC-Country-profiles-Syria.pdf
27. Climate change in the Fertile Crescent and implications of the recent ..., accessed July 8, 2025, https://www.pnas.org/doi/10.1073/pnas.1421533112
28. The Drought That Felled Assad - FPIF - Foreign Policy in Focus, accessed July 8, 2025, https://fpif.org/the-drought-that-fell-assad/
29. Did Drought Trigger The Crisis In Syria? - Footnote, accessed July 8, 2025, https://footnote.co/did-drought-trigger-the-crisis-in-syria
30. Climate Change Lessons from the Ottoman Empire - International Studies, accessed July 8, 2025, https://inst.colostate.edu/news/what-the-ottoman-empire-can-tell-us-about-climate-change/
31. Pollen-inferred palaeoclimatic patterns in Syria during the Little Ice Age, accessed July 8, 2025, https://journals.openedition.org/mediterranee/7220
32. CLIMATE CHANGE AND CRISIS IN OTTOMAN TURKEY AND THE BALKANS, 1590-1710 Sam A. White - Koechy, accessed July 8, 2025, http://sci.martinkoechy.de/Climate_Change_and_the_Middle_East_2006_Proceedings/07_the_past_as_a_key_for_the_future.pdf
33. An Environmental History of the Ottoman Arid Frontier, 1500–1700 ..., accessed July 8, 2025, https://www.carsoncenter.uni-muenchen.de/download/staff_and_fellows/projects/project_husain.pdf
34. A Climate of Confessionalization: Famine and Difference in the Late Ottoman Empire - Smith Scholarworks, accessed July 8, 2025, https://scholarworks.smith.edu/cgi/viewcontent.cgi?article=1016&context=env_facpubs
35. Ancient temperatures | Ancient Ports - Ports Antiques, accessed July 8, 2025, https://www.ancientportsantiques.com/ancient-climate/temperature/
36. Agriculture in ancient Rome - Wikipedia, accessed July 8, 2025, https://en.wikipedia.org/wiki/Agriculture_in_ancient_Rome
37. Roman Syria and the Near East - Getty Museum Store, accessed July 8, 2025, https://shop.getty.edu/products/roman-syria-and-the-near-east-978-0892367153
38. 'Granary of Rome': Can the Houran's wheat survive climate change and war? - Syria Direct, accessed July 8, 2025,

https://syriadirect.org/granary-of-rome-can-the-hourans-wheat-survive-climate-change-and-war/
39. Elaion. Olive Oil Production in Roman and Byzantine Syria-Palestine. - ResearchGate, accessed July 8, 2025, https://www.researchgate.net/publication/332576575_Elaion_Olive_Oil_Production_in_Roman_and_Byzantine_Syria-Palestine
40. Afrin Syria: a visit to the land of olives (2025) - Travelling The Unknown., accessed July 8, 2025, https://travelingtheunknown.com/afrin-syria-a-visit-to-the-land-of-olives-2025/
41. Long-ago freeze carries into the present - Harvard Gazette, accessed July 8, 2025, https://news.harvard.edu/gazette/story/2016/02/long-ago-freeze-carries-into-the-present/
42. Late Antique Little Ice Age - Wikipedia, accessed July 8, 2025, https://en.wikipedia.org/wiki/Late_Antique_Little_Ice_Age
43. Ancient trash mounds unravel urban collapse a century before the end of Byzantine hegemony in the southern Levant | PNAS, accessed July 8, 2025, https://www.pnas.org/doi/10.1073/pnas.1900233116
44. Chapter 9 Continuities and Discontinuities in the Agriculture of the Levant in the Late Antique and Early Islamic Period in - Brill, accessed July 8, 2025, https://brill.com/abstract/book/9789004689350/BP000018.xml
45. Medieval Climate in the Eastern Mediterranean: Instability and ..., accessed July 8, 2025, https://www.mdpi.com/2073-4433/10/1/29
46. Vegetation and Climate Changes during the Bronze and Iron Ages (~3600–600 BCE) in the Southern Levant Based on Palynological Records | Radiocarbon | Cambridge Core, accessed July 8, 2025, https://www.cambridge.org/core/journals/radiocarbon/article/vegetation-and-climate-changes-during-the-bronze-and-iron-ages-3600600-bce-in-the-southern-levant-based-on-palynological-records/BDE82D9216327EA34C71CF9F64FF3C46
47. Hydroclimatic variability in the Levant during the early last ... - CP, accessed July 8, 2025, https://cp.copernicus.org/articles/12/75/2016/
48. Climatically induced Lake level changes at Lake Van, Turkey, during the Pleistocene/Holocene transition - ResearchGate, accessed July 8, 2025, https://www.researchgate.net/publication/248816880_Climatically_induced_Lake_level_changes_at_Lake_Van_Turkey_during_the_PleistoceneHolocene_transition
49. Speleothem-based climate proxy records Research - Geological Sciences - University of Florida, accessed July 8, 2025, https://geology.ufl.edu/people/faculty/dr-oana-alexandra-dumitru/research/speleothem-based-climate-proxy-records-research/
50. Climate change, adaptive cycles, and the persistence of foraging economies during the late Pleistocene/Holocene transition in the Levant | PNAS, accessed July 8, 2025, https://www.pnas.org/doi/10.1073/pnas.1113931109
51. The 4.2 ka BP event in the Levant - CP, accessed July 8, 2025, https://cp.copernicus.org/articles/14/1529/2018/

52. Beyond megadrought and collapse in the Northern Levant: The chronology of Tell Tayinat and two historical inflection episodes, around 4.2ka BP, and following 3.2ka BP - PubMed Central, accessed July 8, 2025, https://pmc.ncbi.nlm.nih.gov/articles/PMC7595433/
53. 8.2-kiloyear event - Wikipedia, accessed July 8, 2025, https://en.wikipedia.org/wiki/8.2-kiloyear_event
54. (PDF) Late Pleistocene and Early Holocene climate and the beginnings of cultivation in northern Syria - ResearchGate, accessed July 8, 2025, https://www.researchgate.net/publication/258138612_Late_Pleistocene_and_Early_Holocene_climate_and_the_beginnings_of_cultivation_in_northern_Syria
55. The Origins of Agriculture in the Near East | Current Anthropology: Vol 52, No S4, accessed July 8, 2025, https://www.journals.uchicago.edu/doi/10.1086/659307
56. A prehistoric cosmic airburst preceded the advent of agriculture in the Levant | The Current, accessed July 8, 2025, https://news.ucsb.edu/2023/021215/prehistoric-cosmic-airburst-preceded-advent-agriculture-levant
57. Ancient Climate Change Transformed Us from Nomadic Hunters to Settled Farmers | Tel Aviv University, accessed July 8, 2025, https://english.tau.ac.il/news/ancient_climate_crisis
58. The history of olive cultivation in the southern Levant - Frontiers, accessed July 8, 2025, https://www.frontiersin.org/journals/plant-science/articles/10.3389/fpls.2023.1131557/full
59. A Tale of Afrin - Youth4Nature, accessed July 8, 2025, https://www.youth4nature.org/stories/tale-afrin
60. Syria's Environmental Crisis Is Its Achilles Heel - The Century Foundation, accessed July 8, 2025, https://tcf.org/content/commentary/syrias-environmental-crisis-is-its-achilles-heel/
61. Byzantine economy - Wikipedia, accessed July 8, 2025, https://en.wikipedia.org/wiki/Byzantine_economy
62. Syria: Olive Cultivation on Hilly Land in the Northwestern Part of the ..., accessed July 8, 2025, https://satoyamainitiative.org/case_studies/syria-olive-cultivation-on-hilly-land-in-the-northwestern-part-of-the-country-and-along-its-mediterranean-coast/