Agriculture: Definition and Overview

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Dorian Q Fuller
University College London

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David R. Harris and Dorian Q Fuller

University College London

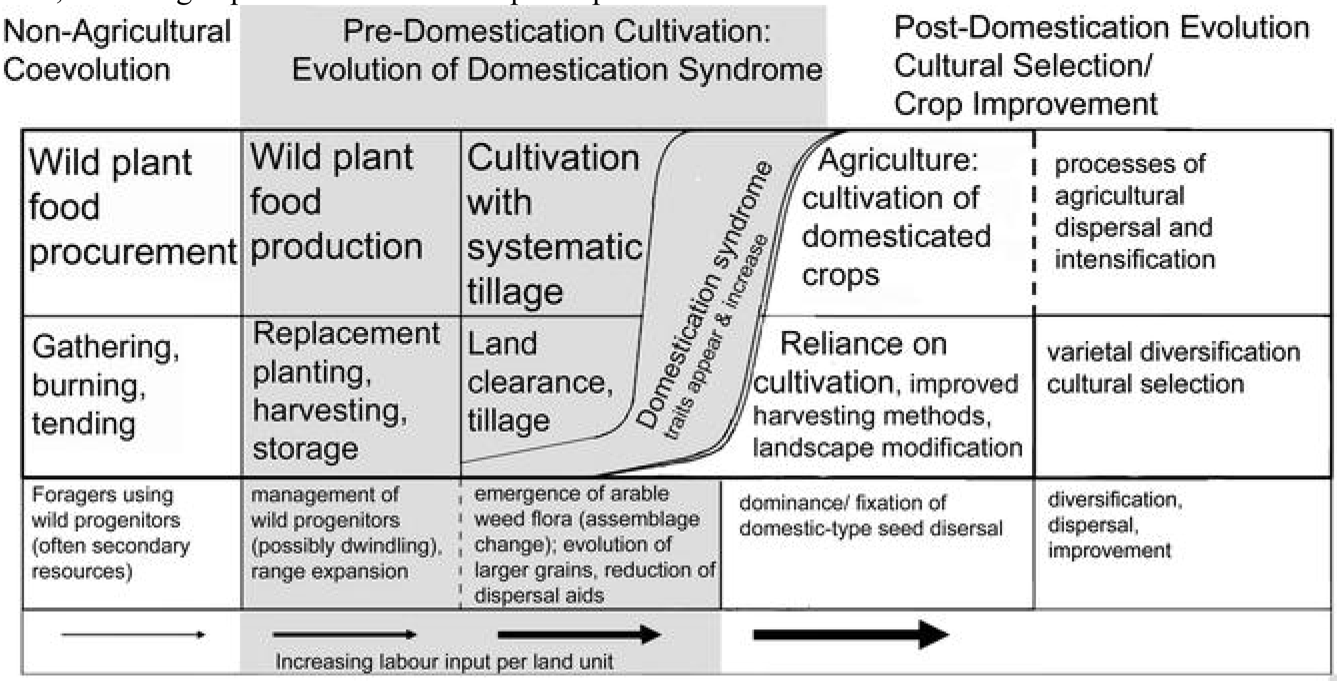
State of Knowledge and Current Debates

Introduction

Agriculture is the most comprehensive word used to denote the many ways in which crop plants and domestic animals sustain the global human population by providing food and other products. The English word agriculture derives from the Latin *ager* (field) and *colo* (cultivate) signifying, when combined, the Latin *agricultura*: field or land tillage. But the word has come to subsume a very wide spectrum of activities that are integral to agriculture and have their own descriptive terms, such as cultivation, domestication, horticulture, arboriculture, and vegeculture, as well as forms of livestock management such as mixed crop-livestock farming, pastoralism, and transhumance. Also agriculture is frequently qualified by words such as incipient, proto, shifting, extensive, and intensive, the precise meaning of which is not self-evident. Many different attributes are used too to define particular forms of agriculture, such as soil type, frequency of cultivation, and principal crops or animals. The term agriculture is occasionally restricted to crop cultivation excluding the raising of domestic animals, although it usually implies both activities. The Oxford English Dictionary (1971) defines agriculture very broadly as "The science and art of cultivating the soil, including the allied pursuits of gathering in the crops and rearing live stock (*sic*); tillage, husbandry, farming (in the widest sense)." In this entry, we too use the term in its broadest, inclusive sense.

In the published literature on early agriculture, there is a tendency for the word agriculture and many of its subsidiary terms to be used vaguely without precise definition, and sometimes their connotations overlap, for example, proto/incipient and shifting/extensive. There is need to clarify much agricultural terminology to avoid confusion (Harris 2007: 17-26), particularly because the multidisciplinary nature of research on the subject leads to many concepts being used that derive from disparate disciplines; principally archaeology, anthropology, biogeography, genetics, linguistics, and taxonomy. In this entry, we cannot review comprehensively all the typological terms currently used in discussions of the origins and early development of agriculture. Instead we focus on the two most fundamental processes that led to agriculture, cultivation and domestication (of plants and animals), and then comment on some of the terms used to denote particular categories of agricultural production. In conclusion, we return to agriculture itself as a process of landscape-scale food production.

This approach, leading from consideration of cultivation through domestication to agriculture (Fig. 1), proposes that agriculture is a form of land use and economy that resulted from the combination of cultivation (a bundle of human actions focused on preparing soil and planting, tending, and harvesting plants) and domestication (a bundle of genetic and morphological changes that have increased the ability of plants to adapt to cultivation). Cultivation and domestication are related as cause and effect, a change in human strategy with consequences in genetic adaptations of another organism, which increased the interdependencies of both. In the next two sections, we explore the nature of and interaction between cultivation and domestication over time in light of mainly archaeological evidence together with some genetic data, including exploration of the concept of “pre-domestication cultivation.”



Agriculture: Definition and Overview, Fig. 1
An evolutionary model from foraging to agriculture, in which the transitions to cultivation, domestication, and agriculture are separated and potential archaeological indicators are suggested (Modified from Harris 1989 and Fuller 2007)

Cultivation

Cultivation is an activity through which humans become directly involved in the management of the lives and life cycles of certain plants. In abstract terms, this can be considered a change from a largely extractive approach to subsistence (collecting) towards a highly regulative one (Ellen 1994), with seasonal scheduling of labor for delayed returns and storable product. In practice, cultivation involves manipulation of soil, water, and other components of the plant environment. At its most basic, it involves sowing of seeds on soil which has been cleared of other vegetation. In low-intensity systems, this may come about through burning of vegetation (slash and burn) or by taking advantage of fresh deposits of silt by river floods (e.g., *décrue* agriculture; Harlan & Pasquereau 1969). It usually involves preparation of the soil by tillage. Tillage methods and tools vary from simple handheld devices (digging sticks, spades, hoes) to team-employed tools, such as the Andean “foot-plough,” to animal-powered ards and true ploughs (Steensburg 1986). Other important variables include the addition of nutrients to the soil by such means as manuring, multiple cropping with nitrogen-fixing species (usually legumes of the family Fabaceae), or using crop rotations with legumes or fallow periods. This represents an important component of cultivation, i.e., scheduling the seasons of sowing and harvesting and interannual patterns in crop rotation and fallowing.

Water is a key input into any cultivation system, and in some regions it had a central role in the origins of agriculture. For example, control of water levels was essential in the development of early rice cultivation in China (Fuller & Qin 2009). Successful cultivation of the perennial ancestor of *japonica* rice involved extending shallow and wetland-margin habitats by clearing competing vegetation, as use of these slightly less-watered microenvironments would have increased grain production. The earliest preserved field systems for rice cultivation consist of small (1–2 m diameter) fields interconnected to each other and to frequent deep water pits that served to drain water from the growing rice.

Cultivation represents an important change in human strategy as people start to manipulate the soil and the composition of plant communities to enhance yields of particular plants later. This has led many researchers to infer that morphological domestication came about through unconscious selection. In other words, people did not set out to domesticate plants but to manipulate productivity through cultivation. The new environment created by cultivation can cause unintended domestication, as the cultivated species adapts to these new circumstances.

In recent years, archaeobotanical research has aimed to identify the practices of cultivation prior to the emergence of domesticated species. Such evidence for pre-domestication cultivation can be inferred from the presence of arable weed assemblages, which may be demonstrated by the statistical composition of wild-seed assemblages or by the modern ecological characteristics of species that recur archaeologically but have little or no known human uses (Willcox 2012). As is well known from later agricultural periods, archaeobotanical assemblages are made up predominately of crops and weeds, together with some gathered fruits and nuts, and this pattern begins to emerge by the earliest Pre-Pottery Neolithic in Southwest Asia and in the middle Neolithic in parts of China (Fuller & Qin 2010). This approach draws on the well-developed tradition in European archaeobotany of using weed-seed assemblages to infer the cultivation ecology of fields (Jones 1988).

Domestication

Domestication is most clearly defined as a biological phenomenon, that is, by traits in crops that result from adaptation to cultivation and by which they differ from close wild relatives. Several recurrent "domestication syndromes" can be recognized as sets of characters that define domesticated crops and characterize domestication as a form of convergent evolution under cultivation (Fuller 2007). The domestication syndrome differs for different kinds of crop plants, according primarily to how they are reproduced, by seed or by cuttings, and what plant organ is the target of selection (grain, fruit, tuber).

The best defined domestication syndrome is that for grain crops, including cereals, pulses, and oilseeds. While all of these traits are the product of cycles of harvesting and sowing from such harvests, the actual selection pressures seem to come from two different aspects of cultivation. First are some traits selected for by harvesting and the crops' growing reliance on humans for seed dispersal. Second are traits that relate to soil conditions, as tilled fields are essentially early successional communities on empty soil, which is generally loose and allows deeper burial of seeds. Although there are six essential syndrome traits in seed crops, only the first four have some chance of archaeobotanical preservation in some species.

First (1) is the elimination of natural seed dispersal, such as through non-shattering rachis in cereals and non-dehiscent pod in pulses and oilseeds. This is often regarded as the single most important domestication trait as it makes a species dependent upon the farmer for survival. It also means that human labor must be used to thresh crops and separate seeds, pods, or spikelets instead of natural dispersal occurring at maturity (Fuller et al. 2010). This trait can only evolve under conditions of harvesting, such as uprooting, use of sickles, or harvesting when crops are mature rather than green. This trait is readily identifiable in cereal rachis or spikelet-base remains, and has been studied in rice, wheats, barley, pearl millet, and maize, but is less evident in the preserved remains of many other crops. However, not all harvesting methods necessarily select for this, which means there are conceivable systems of “non-domestication cultivation” (Hillman & Davies 1990), or there may be weak selection leading to very protracted evolution of this trait within populations (Fuller 2007; Allaby 2010). It is worth noting that any individual plant, or archaeological specimen, either has wild-type or domesticated-type dispersal, but domestication is working on populations, and therefore domestication status should be determined for assemblages as representative of past populations. Recent archaeobotanical evidence tends to suggest relatively weak selection for this trait (Fuller et al. 2010).

A second connected trait (2) is reduction in aids to wild seed dispersal. Plants often have a range of structures that aid seed dispersal, including hairs, barbs, awns, and even the general shape of the spikelet in grasses. Thus domesticated wheat spikelets are less hairy, have shorter or no awns, and are plump, whereas in the wild they are heavily haired, barbed, and aerodynamic in shape. Varieties of wild rice are always awned and heavily barbed, while many cultivars are awnless and those with awns have fewer barbs. Rather than being positively selected by harvesting, this comes about by removal of natural selection for wild-type dispersal adaptations, and therefore under domestication, such traits require less metabolic expenditure. This trait may sometimes be visible in archaeobotanical material but is rare and non-diagnostic and does not provide a definitive means of identifying domestication archaeologically. Because this trait shifts gradually and non-diagnostically, it can be regarded as indicating “semidomestication.”

Two additional traits of the domestication syndrome may be widespread, but they are not recoverable archaeologically: (3) synchronous tillering and ripening, sometimes including a shift from perennial to annual. Planting at one time and harvesting at one time will favor plants that grow in synchronization. Another trait (4) is a more compact growth habit with apical dominance, such as a reduction in side branching and denser spikes or seed heads. In some species, such as in several pulses, this involved a shift from a climbing habit to self-standing. Harvesting methods, like those that select for non-shattering types, can also favor plants with single and compact parts to be harvested.

Two more important traits are thought to relate primarily to an aspect of soil conditions, i.e., planting seeds into more deeply tilled soils. These are traits that relate to rapid germination and early growth. On the one hand (5) is the loss of germination inhibition. In the wild, many seeds will only germinate after certain conditions have passed – conditions of day length and temperature – or after the seed coat is physically damaged. In wild legumes, for example, this may mean that 90 % of seeds will fail to germinate. By contrast, crops tend to germinate as soon as they are wet and planted. This is simply selected by planting as those seeds that do not germinate will fail to contribute to the next harvest and subsequent crops planted from it. This is regarded as a key domestication trait, especially in pulses and pseudo-cereals (e.g., *Chenopodium* spp.) This change is often signalled by changes in the seed, such as thinner and less ornamented seed coats. On the other hand it is a trait, widely studied in archaeobotany, that can be regarded as a “semidomestication” trait. Trait 6 is increasing seed/fruit size. This is likely to be selected for by open environments and deep burial in disturbed soils. This has the added advantage of increased seed weight which tends to increase harvest yields from a given number of crop plants. Comparative studies, for example, between related species, show that larger seeds germinate more quickly and effectively than smaller seeds, and thus this should be selected for by tillage and cultivation generally. As seeds readily preserve, archaeological populations of them can be measured to track changes in average sizes and size ranges, to trace this trait over time. In the case of cereals, selection seems to be focused on seed thickness/breadth rather than length (Fuller et al. 2010).

While for seed crops, predominance of the above traits marks domestication, the end of a process of biological evolution, the determination of domestication sequences is much more difficult in vegetatively cultivated plants such as roots and tubers (Hildebrand 2003, and see the section below on Vegeculture). Because harvest of tubers focuses on a starchy storage organ rather than a reproductive organ, harvesting practices by humans are unlikely to pose strong selective pressures on the next generation. In addition, because tuber plants tend to be perennials, the harvested individual will tend to grow back, reducing the potential to select for improvements across generations. In many cases, cultivation practices may induce the useful part of the plant – the starchy organ – to exhibit phenotypic alteration without changes in its genotypic makeup, such as the improved tuber size produced by yams in loosened, prepared soil as opposed to harder unprepared soils (Chikwendu & Okezie 1989). Thus tuber crops can be cultivated for long periods and on an extensive field scale without undergoing morphological domestication. In addition, archaeologically recovered tuber fragments (parenchyma) tend to preserve few morphological attributes relevant to phenotypic or genotypic change. There is some research which suggests that micro-remains such as starch grains have increased in size with tuber domestication (Piperno 2012). As a result of these factors, the study of early vegecultural systems tends to focus on establishing the presence of potential crop species and inferring practices of landscape modification and management, such as soil mounding, ditch digging, and vegetation burning (see, e.g., Denham 2007).

Specialized Types of Livestock Management and Crop Production

In this section, we examine briefly several distinctive types of agriculture that developed over time into specialized systems focused on the production of food and often also secondary products such as hides, hair, wool, building materials, and many other useful items.

Mixed Crop-Livestock Farming

One of the most significant variables in the historical differentiation of agricultural systems is whether domestic livestock were fully integrated with the processes of crop cultivation as beasts of burden and agents of soil fertilization as well as producers of food. Such systems of "mixed farming" or "agropastoralism" developed early in only a few regions. They did so most comprehensively in Southwest Asia (and later in Europe) where domesticated herd animals – cattle, sheep, goats, and pigs – were raised in close conjunction with wheat, barley, and other cereal and pulse crops as producers of meat, milk, hides, hair, wool, and dung and as traction animals used for ploughing, load-bearing, and other purposes (Harris 2002). A comparable system of mixed farming evolved in East and Southeast Asia where water buffaloes became an integral component of the system of wet-rice (padi) cultivation (Hoffpauir 2000), although this may have been millennia after rice had spread throughout China and much of Southeast Asia (Fuller et al. 2011).

In other regions of early agriculture where domestic herd animals were present, they were not fully integrated with crop cultivation as providers of food, fertilizer, and traction. Thus, in northern tropical Africa, cattle, camels, sheep, and goats, and in the Andean region of South America camelids (llama and alpaca), were not fully incorporated into indigenous systems of cereal, pulse, and root-crop cultivation.

Pastoralism

The full incorporation of domestic herd animals into systems of mixed farming requires permanent facilities such as barns, sheds, stalls, fenced fields, and other enclosures for confining the animals and controlling their movements. This contrasts with pastoral systems that are characterized by more mobile methods of management. The term pastoralism derives from the Latin *pastor*, meaning a herdsman or shepherd, and it applies to mobile systems in which the herd animals, principally sheep, goats, cattle, horses, donkeys, camels, llamas, alpacas, and reindeer, are raised to provide food and other products and as pack and riding animals. The essence of pastoralism is that people move with their animals. The spatial and temporal scales of their movements range from short daily movements of flocks and herds to and from pastures near their owners' settlements (diurnal grazing) to longer seasonal movements by part of the local community with their animals to higher and/or more distant pastures (transhumance), to the most fully mobile system in which families migrate from pasture to pasture with their herds throughout the year and from year to year (nomadic pastoralism). Nomadic pastoralists own and largely depend on their animals, although they have historically obtained some of their food and other supplies by trading with or raiding settled agricultural communities. In fact, all nomadic pastoralists depend to some degree on crop products for their food and often also for supplementary fodder for their animals.

Few if any fully nomadic pastoral groups still exist in the modern world, but in the historical and prehistoric past, this way of life was followed extensively in the deserts of northern and eastern Africa and southwestern and central Asia. The pastoralists' herds consisted mainly of sheep and goats, with the roles of horses and camels varying from region to region, and in the high latitudes of Eurasia a variant form of reindeer pastoralism became established (Ingold 1980).

Horticulture

Horticulture has two contrasted connotations in the literature on traditional agricultural systems and the origins of agriculture. The first relates directly to the origin of the word from the Latin *hortus*, meaning garden (juxtaposed to *ager*, field), and in this literal sense it refers to the cultivation of plots of land adjacent or quite close to the houses of the cultivators. Such gardens are normally smaller than fields, which are usually located farther from their associated settlements. A greater variety of plants, especially perennial shrubs and trees, tend to be cultivated in gardens than in fields, which are commonly devoted to one or only a few types of crop. Also, whereas most fields are cultivated in seasonal cycles, gardens are usually tended continuously, especially in the tropics where long growing periods favor year-round production. Another distinctive feature of house gardens is the presence in them of many adventitious wild and weedy plants. They add to the floristic and structural diversity of the plant community and enhance its ability to provide a great variety of edible, medicinal, and other products such as flowers, fibers, dyes, containers, and construction materials (see, e.g., Coomes & Ban 2004).

The contrasts in size and floristic diversity between gardens and fields are widely recognized in the literature on early agriculture, for example, in the terms "fixed-plot horticulture" and shifting or "swidden" cultivation and the German *gartenbau* and *ackerbau*. Small, continuously tended plots close to dwellings have been proposed as probable arenas of early plant domestication (Harris 1973: 398-401), but very little archaeobotanical research on past garden cultivation has as yet been undertaken.

Secondly, the terms horticulture and gardening have been used to denote agricultural systems that combine field cultivation of annual root and/or seed crops with growing mainly perennial tree, shrub, and herbaceous plants in gardens – a mixed cropping system that, when trees are a major component, is sometimes alternatively described as agroforestry. This connotation of horticulture has been used particularly in descriptions of traditional, and by implication early, systems of cultivation in Melanesia and the Pacific Islands, but this usage tends to obscure the useful distinction between field and garden cultivation.

Arboriculture

The term arboriculture, from *arbor* the Latin for tree, is used to specify agricultural systems focused exclusively or largely on the cultivation of trees and shrubs for the production of fruits and seeds and, in some species, also for ancillary products such as wood for construction and leaves for thatch, fiber, etc. The term, which is sometimes equated with agroforestry (see above), refers mainly to the specialized cultivation of fruit- and nut-bearing trees and shrubs in single- or mixed-species orchards and plantations. It can refer also to plantations of trees for timber production, although this process is more usually described as forestry.

Arboriculture differs from horticulture in that the plants are grown in less floristically diverse communities on larger landholdings. Traditional systems of arboriculture include oil-palm plantations in tropical West Africa and olive, almond, and walnut orchards in the circum-Mediterranean region. Arboriculture has attracted much less attention in the literature on the beginnings and early development of agriculture than the cultivation of cereal, pulse, and root crops, and fruit- and nut-bearing trees are likely to have been a much more important source of food among many hunter-gatherer groups than among early farmers (Harris 2012: 37-9). It tends to be difficult to differentiate specialized arboriculture from more floristically mixed traditional systems of horticulture, and it is seldom possible to do so on the basis of archaeobotanical data alone (see, e.g., Gosden 1995 and Latinis 2000). At present, most of what can be inferred about arboriculture in premodern times comes from historical and ethnoecological evidence.

Vegeculture

The word vegeculture is used to describe agricultural systems that produce mainly root and tuber crops with underground storage organs consisting of starch-rich roots, root and stem tubers, corms, and rhizomes. The crops are reproduced asexually by planting pieces of a parent plant such as parts of tubers, stem cuttings, or sprouts, rather than being grown from seed. Vegetative reproduction made possible the domestication of tuberous plants by replicating the characteristics of parent clones and then selecting and multiplying useful phenotypic variations that arose in planted stock, such as unusually large or smooth-skinned tubers. The process did not involve directional genotypic change from wild progenitor to domesticate as occurred in seed-crop domestication. Root and tuber domestication has taken place within the limits of phenotypic variation determined by an unaltered genotype, but morphological changes under domestication have nevertheless been substantial, for example, decreased flowering and in tubers changes towards greater size and starch content and reduction in bitterness and in the numbers and length of thorns.

Although root and tuber and seed crops are often cultivated together, vegeculture is the traditional mode of agricultural production in many parts of the humid and seasonally dry tropics. Until recently, little macrobotanical evidence of vegeculture had been found because the soft tissues of root and tuber crops are seldom preserved (except in very dry or waterlogged archaeological contexts), but advances in microbotanical techniques for identifying remains of tuberous plants in the form of phytoliths (silicified particles of plant tissues), parenchyma (vegetative storage plant tissues), and starch grains preserved in sedimentary deposits are now beginning to illuminate the prehistory of vegeculture in several regions of the tropics (Hather 1994; Fullager et al. 2006; Piperno 2012).

Agriculture as Landscapes of Food Production

The beginnings of food production represent a strategic shift in human behavior, towards the manipulation of the soil environment and through an influence on the composition of plant populations grown in that soil, via preferential seeding and tending of one or a few species. While cultivation may involve a range of practices, and these will tend to select for morphological domestication, at least in seed crops, we can define agriculture in relation to the scale of cultivation, its prominence in local landscapes and in contributing a major component of human diet. In this sense, *agriculture* is the form of land use that represents a *change in the landscape*, as people regularly cultivate, raise, and focus more attention on domestic plants and/or animals. Agriculture creates fields for larger-scale production of crops and livestock. While small-scale cultivation may involve a few plants, agriculture involves the creation of substantial fields of sown vegetation on such a scale that it should, in principle, be recognizable in regional palaeovegetation datasets, recoverable from palaeosols, and a prominent part of the inferred source of archaeological plant remains. How one distinguishes agriculture from small-scale cultivation varies according to the parameters of particular geographical and cultural contexts.

Irrigation systems are one notable and widespread way in which distinctive landscapes of agriculture have been created. Control of water can be focused either on its removal (drainage) or by adding water to otherwise locally dry areas to allow cultivation where rainfall is insufficient to enhance productivity. In riverine agriculture, such as that associated with ancient Mesopotamia and Egypt (Butzer 1976), this took the form of canals and basins that helped to conserve floodwater and distribute it more evenly and widely. In some mountain environments, such as the Andes, canal systems, often closely associated with cultivated terraces, were also developed to bring steep slopes into agricultural production (Donkin 1979). Some irrigation systems incorporated manual water-lifting devices, such as the *shaduf* which was widespread in Egypt and Southwest Asia by c. 1,500 BCE and allowed buckets of water to be raised above the level of canals and fed onto the fields. By the Classical era, cattle-driven water wheels (*saqia*) made lifting water more efficient and increased the extent of arable lands in river valleys. In regions that relied on rainfall for cultivation, deep wells to tap into groundwater, and surface reservoirs (tanks), were developed to store water. In some of the driest margins of cultivation around the Iranian plateau, in Central Asia, Arabia, and the Sahara, systems of underground tunnels or galleries (*qanats*, *karez*, *foggara*) began to be built several thousand years ago to collect subsurface water from piedmont slopes and direct it out to fields and palm groves in the adjacent plains (see, e.g., English 1968; Magee 2005).

Many other types of agricultural landscape, not referred to here, were developed in premodern times as an increasing proportion of the inhabited earth's surface was transformed by agriculture and as the human population became progressively more dependent through the Holocene, for its food and other needs, on a growing number of domesticated plant and animal species.

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