AGRICULTURE. Archaeologists have long recognized the critical importance of farming as a primary source of food, fibers, and raw materials in most past societies, and in all complex, urban societies. Since the 1960s both the techniques by which past agricultural practices can be studied, and the conceptual frameworks within which agricultural change can be understood, have been vigorously debated.

Archaeological Evidence for Agriculture. Agricultural systems, unlike pottery or architecture for example, are sets of processes that leave no direct traces. Past farming can, however, be studied through its impact on three key classes of material remains: the husbanded plants and animals, the landscape in which they were managed, and the humans for which they were the diet. Animal and plant remains of some form—bones, seeds, phytoliths, pollen—are abundant in archaeological deposits of virtually all agricultural settlements. They can be used to address two main questions: (1) which species of plants or animals were husbanded? and (2) how were they managed? Although species can usually be identified relatively easily, as indicators of agricultural systems and change they are difficult to interpret unless evidence for husbandry practices is also obtained. In the case of crops the associated weed floras can identify irrigation, manuring, or weeding practices; for animals, ageing and sexing of bones are among the tools that can be used to reconstruct herding practices.

Evidence of environmental manipulation—especially the cultivation of fields—can be found in the physical changes in the landscape, such as field patterns, the construction of raised fields, or the construction of irrigation canals. Pollen from lake cores, geoarchaeological fieldwork, and charcoal from excavations can pick up environmental changes associated with agriculture such as deforestation or erosion. Human diet—not a direct index of agricultural practice, but obviously linked—is recorded in bone chemistry and pathological conditions of human skeletal remains, as well as in occasional finds of coprolites and preserved stomach contents.

No single type of evidence is adequate in itself; animal and plant remains are often open to varying interpretations of their economic implications, and landscape archaeology is difficult to date. An approach which first seeks to integrate different types of agricultural evidence, and then seeks to integrate these with other types of archaeological evidence (e.g., changing settlement patterns) for wider cultural change, is ideal but rarely achieved. As with archaeological evidence for other processes, the study of long-term change in agricultural patterns is vital in seeking causal explanations. All too often, the archaeological record of agriculture in a given region consists of a small collection of key sites at which adequate evidence for ancient agriculture has been recovered and published, separated by long gaps in distance and time.

Agricultural Ecology. Basic features of the earth's climate and topography circumscribe agricultural options in many regions. In areas of low rainfall or high altitude, crop production may be very difficult, and pastoralism is the dominant form of agriculture. Examples include the high altitude grasslands of the Andes, at over 13,123 feet (4,000 m), on which llamas and alpacas are herded, the arid steppic interiors of the Near East and Africa, where pastoralists herd sheep, goats, and cattle, and the reindeer herders of northern Asia. In arid areas with major river systems, irrigation agriculture is essential for the support of any settlement, for example in Egypt, the Indus valley and lower Mesopotamia.

Global patterns of insolation and rainfall do result in global patterns of crop types: for example, tuber crops are predominant in equatorial regions. These may have been of great significance at the origins of agriculture, but although the specific technology in a given system is partly determined by climate and topography, they have changed relatively little since the beginnings of agriculture. Explanations for the major changes that have occurred in agricultural systems must be sought in human actions.

Early Agriculture. Agriculture is one end of a gradient of human interaction with plants and animals. Ethnographic studies have shown that procurement of food by hunter-gatherers often involves different degrees of manipulation of organisms and their environments. These may range from almost incidental effects such as the dispersal of yam tubers during harvesting by Australian aborigines, to large-scale environmental manipulation by burning vegetation to increase yields of game or seeds, recorded ethnographically in Australia, Africa, and the Americas. Small-scale cultivation of wild plants is also known. Agricultural systems differ in that manipulation of resources extends beyond the environment, to the manipulation of plant and animal populations. Human interference in the reproductive behavior of managed plants and animals results in the fundamental genetic changes in the behavior and structure of plants and animals that are defined as domestication. The package of environmental manipulation with domesticated plants and animals is often seen as representing a major discontinuity in the gradient of human interaction with the environment.

Ethnographic and archaeological evidence shows that the appearance of agricultural systems is usually linked to the appearance of sedentary villages. This is not a simple case of cause and effect: sedentary hunter-gatherer villages are known from a number of resource-rich areas such as the Pacific coast of North America and the *Natufian period of the Levant, and some hunter-gatherer societies have engaged in small-scale cultivation without significant effects on their overall economy. It is generally true, however, that

the introduction of agriculture is linked to an increase in population and in the number and size of sedentary villages. This is particularly clear in the case of the spread of the Neolithic package of crops and domesticated animals from the Near East into Europe. Although the reasons for the spread of agriculture are still the subject of speculation, there is no doubt that agriculture has the potential to be more productive than foraging. In this case, productivity is not only a matter of yield, but also of producing predictable crops that can be easily stored. Agricultural systems also have the important property of spreading easily, even into areas that are marginal for the wild ancestors of the crops and animals concerned: for example, wheat and barley have spread over most of the temperate world, although their wild ancestors are restricted to their Near Eastern homeland. Agriculture has therefore had an important role both in supporting higher populations and in extending areas of human settlement.

Understanding of the early history of agricultural systems is handicapped by limited archaeological data on any aspect of early societies, particularly in the Americas and southeast Asia. This is reflected in the controversy that surrounds basic questions on the date and area of domestication of the main crops. In the case of both North and South America, however, small-scale cultivation of domesticated crops (domesticated animals were less important than in Eurasia) as part of a hunter-gatherer economy seems to have continued over several millennia, prior to the development of fully agricultural societies. In North America, bottle gourd, sumpweed, sunflower, and other species entered part-time horticulture between the third and first millennia B.C. and in Mesoasmerica and the Andes, crops such as maize, beans, squash, potato, and cotton may have been domesticated by 6000 B.C. It is increasingly clear that earlier models for the emergence of agriculture, which draw heavily on Nikolai Vavilov's concept of seven narrowly delineated centers of origin, do not take account of what is a much more complex and geographically widespread set of processes.

Identifying agricultural change in early, preurban societies and linking it to wider socioeconomic patterns is still a major challenge for archaeologists. There are two main reasons for this: first, that early archaeological sites and the evidence they contain are usually less well preserved and difficult to date; second, that there are relatively few excavated sites over what are usually long periods of prehistory. In general, for these early periods, attention has focused on the origins of agriculture rather than its subsequent development. There is evidence from a number of areas, such as late Jomon Japan, that agriculture can initially form a relatively minor part of food procurement systems, and key variables associated with agriculture, such as population increase, only come into play once agriculture has been more fully adopted. In contrast, agriculture in the Near East seems to have spread fast, as an identifiable Neolithic "package." Clearly generalizations about the impact of agriculture on hunter-gatherer societies may be hard to sustain on a cross-cultural basis.

Agricultural Intensification. Agricultural intensification is often cited as a key factor in the evolution of complex—often urban—societies. Intensification—a concept drawn from agricultural economics—can be a nebulous term, but usually means a great input of resources—especially labor—into a given area of land, or in other words, a high input, high output system. The appearance of new crop species or new agricultural techniques in the archaeological record is often interpreted as evidence of intensification.

Cases in which new crops apparently correlate with the beginnings of complex society include the spread of maize into lowland areas of Mesoamerica during the Formative period (2500 B.C. onward), of summer-season crops such as sorghum and cotton into India in the second millennium B.C., maize and the development of hierarchical societies in the Amazon in the first millennium B.C., rice into Japan at the beginning of the Yayoi period (300 B.C.), and the appearance of domesticated grape and other tree fruits at the beginning of the Bronze Age in the Aegean, which has been linked to the beginnings of urban civilization there.

Three key examples of intensification are irrigation, the engineering of fields, and the introduction of the plow. Where radial canals have been constructed to carry water from rivers to fields, surface traces of canals often exist that can be dated by comparing their path with the distribution of settlements of known dates. In Mesopotamia, field surveys have traced the development of canal systems from sites such as Choga Mami, dating to about 5000 B.C. through to the Medieval period. In areas such as the Indus Valley and the Nile Valley where irrigation occurs from the annual flooding of the river, traces of the system of dikes and basins that held back the water are buried under alluvium. Even though direct evidence for irrigation may be lacking, however, the aridity of these areas means that agriculture must have depended on irrigation. The beginnings of urban civilization in all three areas in the third millennium B.C. are often thought to be causally linked to the necessity for central administrative structures with which to operate large-scale irrigation systems.

Elsewhere, irrigation has often been linked to the development of specialized forms of fields. In the tropical zone, raised fields have the advantage of allowing drainage in poor soils as well as irrigation. Raised-field systems are most frequent in Middle and South America. Major civilizations of Mesoamerica such as the *Maya and *Teotihuacán were fed by irrigated raised-field systems. That the Maya culture was thought to have depended on slash-and-burn agriculture until the late 1970s is an indication of the difficulties in locating field systems in what is now tropical forest. Terracing of fields is another form of agricultural development with high labor input for construction and maintenance. Such terraces are also very difficult to date, but are a major feature of the landscape in the eastern Mediterranean and form a crucial part of irrigation systems in the wet-rice agriculture of southeast Asia. In temperate Eurasia the introduction of the animal-drawn plow is often cited as evidence of a form of intensification. The plow seems to have spread from the periphery of the Near East to much of Europe around 3000 B.C. allowing expansion of population into previously uncultivable areas.

Those agricultural changes that can be identified as intensification are obviously linked to increased population: this both creates the demand for intensification to occur, and provides the increased labor that most forms of intensification require. The issue of causality remains controversial: does the introduction of a new crop really destabilize and change an existing agricultural system, or will new crops be drawn into cultivation by increasing demand? To what extent does a successful agricultural system remain stable? Is the rise of a complex society always linked to major shifts in agricultural production—in temperate Eura-

sia, for example? It is likely that the answers to such questions cannot be framed in simple terms of one or two active agents, but approaches that consider systems as a whole can be complex and difficult to quantify. In the formation of the great irrigated civilizations, trade seems to have played as vital a role as agriculture.

Similar issues have to be considered when discussing the subject of agricultural decline or collapse. In view of the obvious, close relationship between complex societies and intensive agriculture, archaeologists are quick to point to mismanagement by farmers as the cause of collapse of a civilization. Empirical evidence does not support such arguments: traditional systems of agriculture today, whether intensive or extensive, have proved to be stable and adaptable. Agricultural systems tend to break down owing to interference by sociopolitical disruption. The causes of agricultural change cannot be sought in agriculture alone; farming is one part—a very important part—of a wider society.

[*See also* AFRICA: ORIGINS OF FOOD PRODUCTION IN; ASIA, ORIGINS OF FOOD PRODUCTION IN, *articles on* ORIGINS OF FOOD PRODUCTION IN SOUTH ASIA, ORIGINS OF FOOD PRODUCTION IN SOUTHEAST ASIA; CHINA; EUROPE: THE EUROPEAN NEOLITHIC PERIOD; MESOAMERICA, ORIGINS OF FOOD PRODUCTION IN; THE NEAR EAST: THE NEOLITHIC AND CHALCOLITHIC (PRE-BRONZE AGE) PERIODS IN THE NEAR EAST; PLANT REMAINS, ANALYSIS OF.]

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