Karl W. Butzer

Civilizations: Organisms or Systems?

Civilizations behave as adaptive systems, becoming unstable when a top-heavy bureaucracy makes excessive demands on the productive sector; breakdowns result from chance concatenations of mutually reinforcing processes, not from senility or decadence

Oswald Spengler's *Decline of the West* (1926) regarded societies as organisms, with an inevitable life cycle of youth, maturity, and decay. This organic analogy had earlier been formulated by Herbert Spencer in his *Study of Sociology* (1872), and was subsequently adapted in a less deterministic fashion in A. J. Toynbee's *Study of History* (1934). Toynbee emphasized the role of creative individuals in the growth of civilizations, and attributed breakdown and disintegration to the failure of creative power among the dominant minority, to alienation of the masses, and to pressures of foreign peoples.

The model of ascendance, climax, and retrogression entered American anthropology with the writings of Julian Steward in the 1940s, and was then formalized in archaeology by the historical-developmental scheme of G. R. Willey and P. Phillips (*Method and Theory in American Archaeology,* 1958). David Clarke (1968) has formulated this model of birth, growth, and death as one of "culture system ontogeny," with formative (florescent), coherent (classic climax), and postcoherent (postclassic) stages, by incorporating Spencer's long-neglected insight that a society is an interdependent system of specialized parts.

Karl W. Butzer is the Henry Schultz Professor of Environmental Archeology at the University of Chicago. After completing undergraduate work and the M.Sc. at McGill University, he received his doctorate at the University of Bonn in 1957. He is particularly interested in the interrelationships between culture and environment, studying archaeological sites and landscape change in several parts of Africa, in Spain, and in Illinois. He is editor of the Journal of Archaeological Science, *and holds the Busk Medal of the Royal Geographical Society. Address: The University of Chicago, 5828 S. University Ave., Chicago, IL 60637.*

A systemic alternative

The integration of the developmental and systemic models represents a significant improvement in analyzing the apparently rhythmic rise and fall of civilizations. But the emphasis remains on ontogeny, and therefore presumes a sequential interplay of predictable processes. In fact, cultures can be more advantageously examined as ecological systems, in which human populations interact with the biophysical environment, as well as among themselves. Such a systemic model is more suitable to explain the archaeological record of relatively simple hunting-gathering "cultures" that responded to repeated internal or external inputs by minor or major transformations, although the basic character of their adaptive system remained unchanged over many thousands of years. The records of such prehistoric systems suggest a steady-state (rather than homeostatic) equilibrium (Fig. 1).

More complex cultures frequently responded to novel inputs by relatively sudden equilibrium shifts, leading to more fundamental sociopolitical transformations, with or without a change of adaptive strategy. It appears that the time trajectories of "high" civilizations, in particular, have tended to resemble a metastable equilibrium pattern marked by thresholds at which "positive" or "negative" shifts of equilibrium level have taken place (Fig. 1). Whereas the established, developmental model for civilizations generally assumes a succession of ever-higher homeostatic plateaus, followed by abrupt collapse, the systemic model proposed here can do justice to both the steady-state and metastable equilibrium concepts, while also allowing for long-term, nondisjunctive directional trends (dynamic equilibrium).

It is therefore possible to view civilizations as ecosystems that emerge in response to sets of ecological opportunities, that is, econiches to be exploited. Over a span of time, a variety of internal (social) and external (environmental) adjustments will inevitably take place; some of these will be "successful," leading to demographic expansion, others "retrograde," requiring demographic curtailment. These demographic trends are commonly associated with, and parallel to, the ups and downs of political power, although this is not always the case. However, political structures generally are less durable than either cultural identity or ethnic consciousness, and these in turn are less persistent than the basic adaptive system on which they are predicated. This is consistent with the ecosystem analogy, since the structural components of a population are devices to ensure adaptive success and not the other way around.

The processes integral to "ascendancy" and "retrogression" are reconcilable with a systemic model. Ascendancy can be identified as a sociopolitical transformation in which structural organization favors an optimal flow of energy within the system. A useful ecological concept is that of trophic levels among biotic communities, in which organisms with similar feeding habits, such as photosynthetic producers, herbivores, and carnivores, define successive tiers

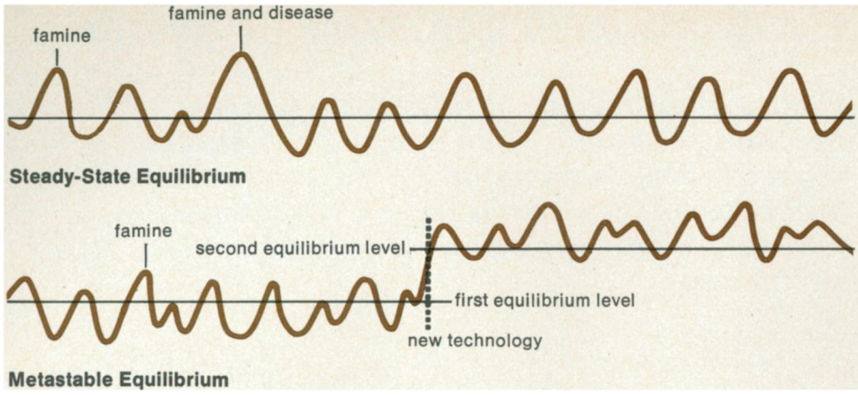

Figure 1. Demographic curves express the quality of human adaptation. One common type of equilibrium is steady-state (*top*), in which recurrent famine and epidemic disease lead to repeated population fluctuations without long-term directional change. In more complex societies, new adaptive strategies may allow one or more jumps in equilibrium level (metastable equilibrium, *below*), and subsequent demographic oscillations may be of smaller amplitude; negative social or environmental inputs can also have a reversed impact. (Equilibrium curves based on Chorley and Kennedy 1971.)

interlinked in a vertical food chain. An efficient social hierarchy comprises several "trophic" levels arranged in a low-angle pyramid, supported by a broad base of agricultural producers and linked to the central, administrative apex by a reasonable number of middle-echelon bureaucratic agencies (see Fig. 2). The vertical structures serve to channel food and information, and an "efficient" energy flow would imply conditions allowing each trophic level to flourish in a steady state or even a dynamic equilibrium.

A flatter pyramid with little or no vertical structure would provide less information flow and so limit the potential productivity of the substrate. This version of the model allows for growth, with new technological or organizational devices, of external or internal origin, favoring expanded energy generation at lower trophic levels. On the other hand, a steeper pyramid, with a top-heavy bureaucracy, would place excessive demands on the producers and so jeopardize the food chain. The steep pyramid model represents a system prone to metastable equilibrium, with external or internal inputs liable to undermine the productive substrate and so to destroy the nonproductive superstructure; the probable result would be a much-simplified pyramid.

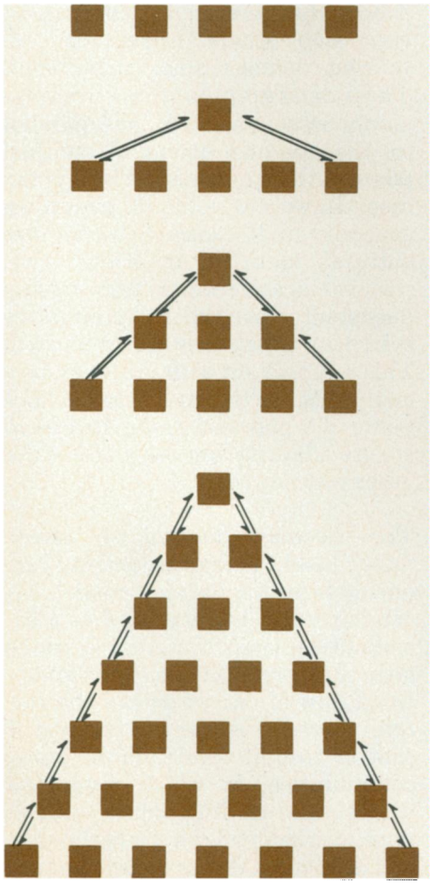

Figure 2. Sociopolitical hierarchies, whether simple or complex, can be compared with the organization of trophic levels in a food chain. These schematic models show different modes of energy and information flow for increasingly complex sociopolitical hierarchies in preindustrial societies. The first model shows no vertical structure, with horizontal but no vertical information flow, and slow change. The second model indicates limited vertical structure, with some vertical information flow, and increased dynamism. The third model depicts elaborate vertical stucture, characterized by efficient energy and information flow, with each level as well as the whole system in steady-state or dynamic equilibrium. The fourth model represents a top-heavy vertical structure, with impeded information flow, increased energy expenditure for system maintenance, excessive demands on the productive substrate, and a metastable equilibrium.

Processes of growth

Both the advantages and difficulties of this ecosystemic view of civilizations can be illustrated and then elaborated with specific reference to ancient Egypt (Butzer 1976, 1980).

The political history of Egypt has traditionally been organized in several cycles: the Old Kingdom (ca. 2760–2225 B.C.), the Middle Kingdom (2035–1668 B.C.), and the New Kingdom (1570–1070 B.C.). Each reached its apex in an episode of strong, central government, followed by a long period of stagnation and eventual decline. The First Dynasty (ca. 3170–2970 B.C.) represents another such culmination of a less clearly delineated protohistoric development. Each phase of political devolution was accompanied by economic deterioration and temporary or substantial demographic decline (see Fig. 3). The greatest population density prior to the radical technological improvements of the last one hundred years was achieved during early Roman times.

We can first examine the processes of growth. Episodes of growth in Egypt were made possible by such innovations as improved irrigation organization, devices for controlled water distribution during bad flood years, lift mechanisms to allow cultivation of marginal areas or several crops per year, as well as new cultigens better suited for poorer or drier soils and for summer cultivation—in an agricultural system originally geared only to postflood, winter crops. These innovations represent the basic range of human impact on an environment that, thanks to the river, remained

undegraded until the construction of the Aswan High Dam.

1. The First Dynasty was preceded by several centuries during which political power was consolidated, a rudimentary bureaucracy organized, and controlled flood irrigation begun. The final unification of Egypt marshalled all resources at the direct or indirect disposal of the pharaoh.

2. The early Old Kingdom saw a strengthening of bureaucratic structures; there also was conscious "development" of the central Delta (see Fig. 4) and its desert margins for stock-raising and high-productivity plantations, including orchards and vineyards.

3. The founding administrators of the Middle Kingdom responded to several centuries of repetitive Nile failure by greater government intervention in food redistribution, to feed the productive population in times of famine. Large-scale internal colonization now focused on draining and settling parts of the Faiyum Depression.

4. A major introduction of the New Kingdom was the *shaduf*, a work-saving bucket-and-lever device to raise water a meter or so from wells or ditches, to water market gardens or tree crops on large estates. The eastern Delta was systematically developed, as a hinterland to the new administrative capital of Pi-Ramesse. The center of demographic gravity now shifted from the narrow Nile Valley to the broad Delta (see Fig. 5), and the new Asiatic dependencies generated additional wealth for Egypt.

5. Colonization of the marshy, northern Delta and the Maryut Depression began 650–525 B.C. during a brief revival of pharaonic power, and resumed after 300 B.C. under the Ptolemies. This foreign dynasty maximized its economic resources by creating efficient administrative centers in each provincial capital, with a formal harbor authority to regulate exchange on the internal waterways. In the Faiyum they completed drainage and achieved a showpiece of agricultural productivity, made possible by a ring of high-lying canals fed by a Nile branch and in turn supplying a string of new cities (see Fig. 6), largely settled by Macedonian colonists. The animal-drawn waterwheel (*saqiya*) began to make possible two crops a year on prime lands, and summer crops such as sorghum were introduced.

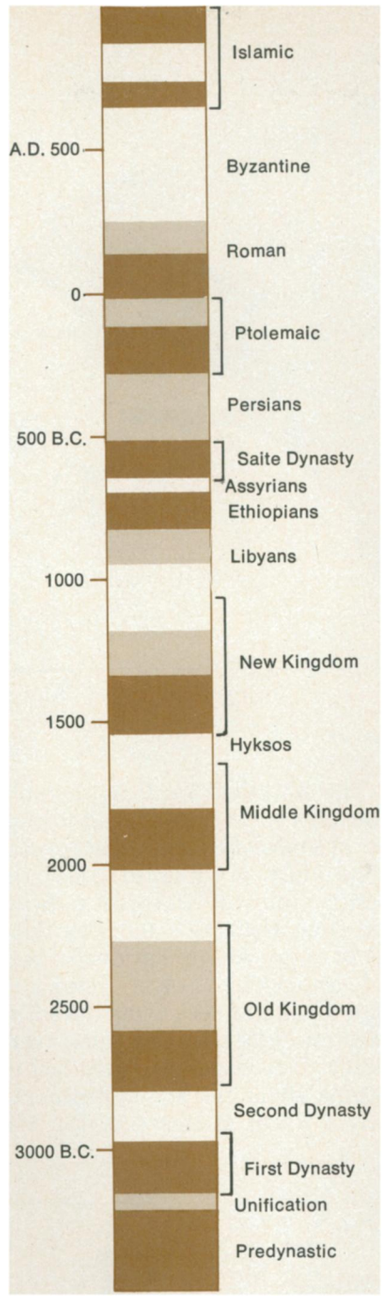

Figure 3. On this Egyptian time-line, periods of increasing population are shown in black, those of decreasing population are in white, and periods of stable population are in color.

The basic impact of such improved organizational efficiency, new technology, or expansion and intensification of agriculture was to increase both the labor force and national productivity. In response, it is probable that the population of Egypt increased from less than a million under the First Dynasty to about five million in the second century B.C.

Processes of decline

It has commonly been assumed that floodplain irrigation provides an ecosystem that is uniquely productive and predictable, one in which environmental inputs do not generate significant change. In fact, however, this is a gross oversimplification.

Predynastic, Old Kingdom, and Middle Kingdom agriculture was based on no more than a rudimentary flood-basin irrigation that lacked the lift technology essential to (1) cultivate the entire floodplain, (2) guarantee a reasonable minimum of food during poor flood years, or (3) allow more than a single crop per plot per year, except in gardens watered by hand. Pharaonic agriculture was extensive, rather than intensive, with perhaps half the agricultural lands used for grazing or in fallow in 2000 B.C., and large parts of the potentially fertile floodplain were still underdeveloped in the eleventh century B.C.

Irrigation was organized not centrally, but locally. Food storage facilities were limited to private domains until the New Kingdom, and even then public redistribution in times of need was ineffective. A substantial body of data shows that flood levels declined drastically during the Second Dynasty (ca. 2970–2760 B.C.), that catastrophic Nile failures recurred at least several times at the end of the Old Kingdom (ca. 2250–2000 B.C), that equally catastrophic, aberrantly high floods marked the second half of the Middle Kingdom (1840–1770 B.C.), and that major, negative readjustment of Nile hydrology took place over several generations shortly after 1200 B.C., when the Nubian floodplain was no longer inundated by the Nile and had to be abandoned.

These facts provide a different perspective for evaluation of the long intervals of economic stagnation, demographic decline, and political discontinuity in pharaonic Egypt. We can now attempt to identify these phases and processes of decay.

1. The Second Dynasty was an era of political instability, revolts, reduced

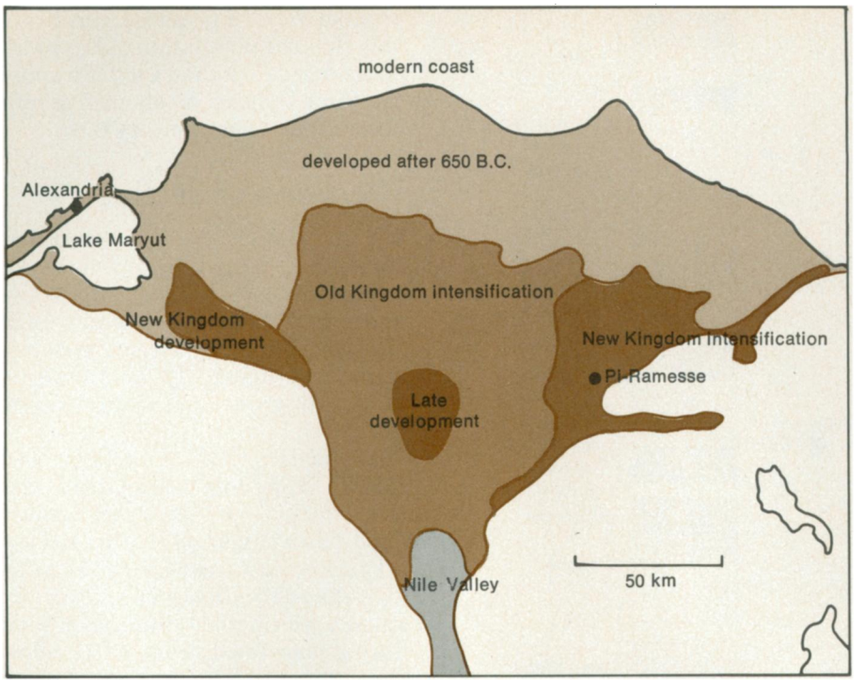

Figure 4. Land use on the central Nile Delta was intensified during the Old Kingdom, when many new villages were founded. Settlement expanded along the sandy margins of the Delta during the New Kingdom; the marshy northern Delta was opened up to large-scale settlement only after 650 B.C. (Waterways of the Nile Delta, which repeatedly changed in number and position, are not shown on this map.)

foreign trade, and probable impoverishment. Nile floods declined by an overall 30%, and in some years failed entirely.

2. Cheops (ca. 2638–2613 B.C.), builder of the Great Pyramid, controlled more personal power and wealth than any other pharaoh, and later royal tombs progressively diminished in size or elaboration. The Fifth Dynasty kings (ca. 2541–2407 B.C.) had to compete with the power of the temples, while the uneconomical policy of setting up perpetual, tax-free mortuary foundations began to withdraw extensive agricultural lands and their produce from the tax base. Under the Sixth Dynasty (ca. 2407–2255 B.C.), the burgeoning aristocracy and upper-level bureaucracy shared in more of the wealth, eventually creating rival power bases in the provinces. But an overall reduction in the size and opulence of funerary architecture, both in the capital and in the provinces, documents progressive economic decline during the Sixth Dynasty. Two centuries of political chaos followed, with periods of civil war, anarchy, catastrophic Nile failures, repeated famines, and even cannibalism. Food stores were plundered, the estates of the rich dispossessed, and hordes of starving people roamed the countryside, threatening the foundations of the social order.

3. The Middle Kingdom pharaohs after 1794 B.C. were reduced to puppets of a powerful family that ruled as prime ministers but failed to keep the country unified. Records indicate that from 1840–1770 B.C. one flood out of three was exceptionally high and destructive (2–4 m above normal), capable of destroying the entire irrigation system several times every decade. But literary sources tell us nothing about the actual process of decline. Then, in 1668 B.C., the Asiatic Hyksos conquered Egypt and held it for a century.

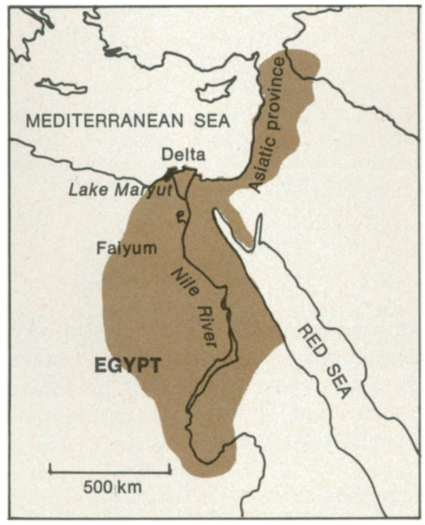

Figure 5. This overview map of New Kingdom Egypt shows the relative locations of the Nile Delta, the Faiyum Depression, and the Asiatic Province.

4. The New Kingdom saw the temple of Amun acquire great wealth and power, and the unsuccessful reaction under Akhenaten (ca. 1350–1334 B.C.) shook Egypt, endangering the Asiatic empire..A reasonable degree of prosperity was eventually restored, but invasion attempts by several barbarian peoples were barely staved off in 1207, 1177, and 1171 B.C., and the Asiatic provinces were lost. Grain prices, compared with prices of nonfood products, increased rapidly to as much as 24 times the standard price. Together with at least six verified food riots or strikes and indications that the government granaries were empty, this documents a severe food shortage between 1153 and 1105 B.C. The agricultural abandonment of the Nubian floodplain, now no longer inundated by the annual floods, ties in these years of starvation with long-term reduced Nile discharge and falling lake levels in sub-Saharan Africa. The government was rife with corruption and could no longer maintain public order. After 1120 B.C. desert marauders terrorized the overtaxed and depopulated countryside. Eventually the high priest of Amun displaced the impotent king, and four centuries of weak priestly or foreign rulers barely held the country together.

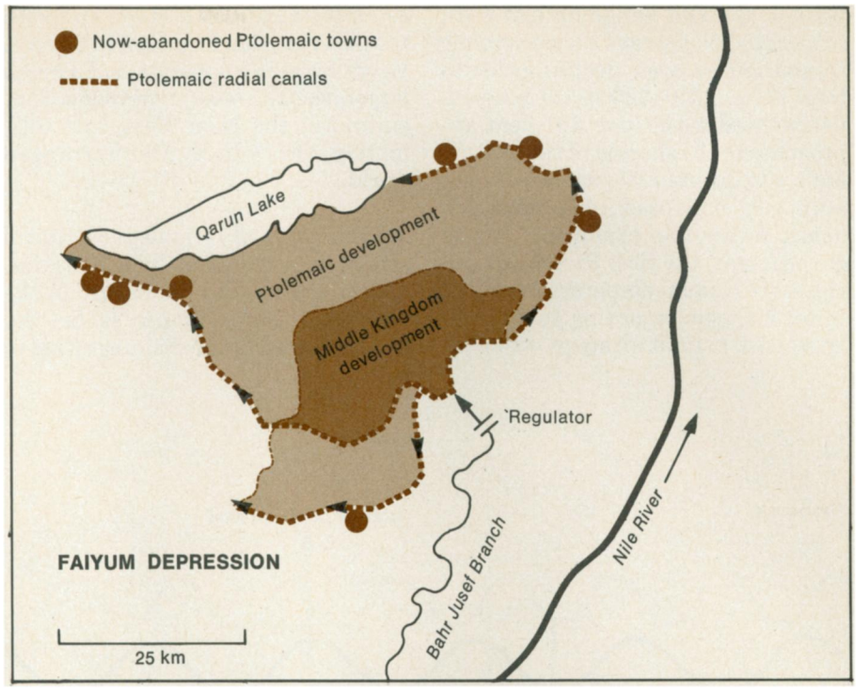

Figure 6. Colonization of the higher parts of the Faiyum Depression took place during the Middle Kingdom; a sophisticated drainage and irrigation system covering the greater part of the Depression was completed under the Ptolemies in the third century B.C. Water was fed into a ring of high-lying canals that supplied a network of local feeders and allowed towns to flourish in the former desert.

5. Egypt stagnated again under intermittent and ineffective Persian rule from 525 to 332 B.C., and the immense social problems of the overcrowded Delta can be inferred from Herodotus's description of about 450 B.C. Following the apex of economic revitalization under the early Ptolemies, Roman rule initially restored stability while population peaked near 5.5 million, despite a policy of calculated exploitation. Government became grossly inefficient by A.D. 200, with overtaxation and a brutal, arbitrary tax-farming system that drove cultivators off the land. In combination with violent religious and civil strife, and the monastic movement, dramatic depopulation reduced Egypt to an underdeveloped economy by the fifth century. Totally demoralized by a millennium of foreign exploitation, the Egyptian people accepted their own particularist version of Christianity and disowned their cultural traditions. After seven centuries of Islamic rule, beginning A.D. 641, they also lost their Coptic Egyptian language and became linguistic Arabs.

The common denominator of each period of decline was rural depopulation and decreasing economic productivity. The responsible processes were complex and involved at least two of three major factors: excessive demands on the productive population; a high incidence of poor or destructively high Nile floods; and insecurity due to political instability, foreign rule, or invasion. Each retrograde phase coincided with negative social developments within, as well as negative environmental or social interventions from without.

In the case of the Old and New Kingdoms, internal social evolution was unfavorable for at least three centuries prior to political breakdown, suggesting that external inputs may have triggered drastic readjustment of a sociopolitical system already in a state of metastable equilibrium. However, for the First to Second Dynasties and the Middle Kingdom there is no tangible evidence of overtaxation; instead breakdown takes place within a century of the first hints of political weakness, arguing for a severe and unpredictable stress exerted on an otherwise functional system. Strong oscillations of productivity since the eighth century B.C. are less coherent, as a result of recurrent foreign intervention.

Identifying systemic variables

Several key variables can be identified in this analysis of the periods of growth and decline. First, a potent but not universal factor is a progressive social pathology, linked to our model of a top-heavy and metastable sociopolitical pyramid. Karl Wittfogel (1957) has described this as progressive overexploitation of the masses by a growing unproductive elite, with resulting social disequilibrium and eventual politicoeconomic collapse. This process can be discerned in the case of the Old and New Kingdoms, as well as during the late Roman and the Byzantine periods. It is not verifiable during the Second Dynasty nor during the decline of the Middle Kingdom.

The importance of leadership, then as now, is equally apparent as a second key variable. The case is best made in reference to strong leadership, since ineffectual leadership speaks for itself. Strong leadership in ancient Egypt is well documented in the case of Ramesses III (1182–1151 B.C.), the last competent ruler of the New Kingdom. Despite two centuries of social stress he marshalled sufficient support to beat off powerful foreign invaders who had destroyed the other kingdoms of the eastern Mediterranean world. He still managed to maintain internal order through the first years of a growing, Nile-related food shortage. His death (possibly by assassination) 2 years after the first food riots then opened the doors to general chaos, unchecked rural depopulation, and economic disaster.

Earlier, the Old Kingdom had been subject to 250 years of socioeconomic stagnation or even decline prior to Pepi II (ca. 2350–2260 B.C.), who experimented with three different approaches to the sharing of centralized authority during a 90-year reign. That authority collapsed only after his death. As another example of strong government, the first Ptolemies and the early Roman emperors managed to milk Egypt according to a calculated cost-benefit strategy, while allowing the totally disenfranchised population to maintain a phenomenal demographic peak for some 500 years.

Foreign intervention is a third critical variable. The military effectiveness of the Assyrian, Persian, Macedonian, Roman, and Arab armies is well known. The Hyksos were equally formidable, as recent evidence shows—powerful, well-armed and armored warriors, using swift, horse-drawn chariots. The Egyptians were only able to dislodge the Hyksos with difficulty, after modernizing their own armies. (Other peripheral peoples never managed to upset the system, and the "Libyan" and "Ethiopian" dynasties, 946–656 B.C., were rooted among immigrants or conquered people already acculturated.) Until the Hyksos invasion, Egyptian society had been remarkably self-sufficient and had functioned to some degree as an approximation to a closed system; after the Hyksos invasion the New Kingdom Empire resembled an open system, and with the first Assyrian incursion in 664 B.C. Egypt became a subsystem of a much larger socioeconomic network that embraced the Near East, and ultimately the whole Mediterranean world.

A fourth critical variable is ecological stress, as a result of Nile behavior. The co-agency of Nile failure in the New Kingdom collapse is beyond question, and in the disintegration of the Old Kingdom, plausible. In Second Dynasty and late Middle Kingdom times, aberrant Nile behavior is not only the single external variable in evidence but the most prominent agent overall. This does not attribute the role of a determinant to Nile behavior. Instead, at a given level of technology, the Nile ecosystem provides a set of opportunities and constraints to agricultural productivity, varying from season to season, as well as from year to year.

The key variables singled out in this Egyptian example are more or less specific to Egypt. A fuller roster of potential variables for consideration would include agricultural productivity and access to resources (Butzer, in press), technology, settlement aggregation, exchange networks for food, raw materials, and finished goods, demography, socioeconomic structures, warfare, as well as political structures and leadership. Together these define a complex set of interrelationships, with a full range of transition from "dependent" to "independent" variables.

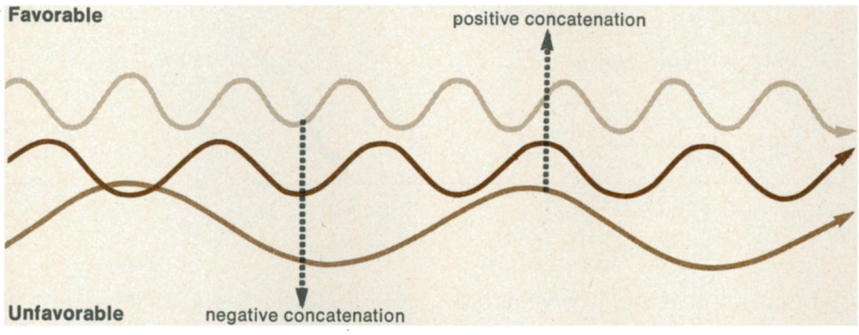

Figure 7. Several processes with varying periodicities may occasionally coincide, reinforcing one another and creating an overall tendency that is strongly unfavorable (low point of trends) or favorable (high point) to the system.

Civilizations as adaptive systems

These systemic variables all contribute to the explication of the interaction between society and environment. Collectively, they help define adaptive systems (in the sense of Buckley 1968), which are characterized by a body of community behavior that reflects perception of the biophysical environment and that adjusts in response to external as well as internal changes.

In terms of general evaluation, it can be argued that complex societies are buffered from external variables by multiple "layers" of technology, social organization, and exchange networks. The instability threshold for such systems is increasingly high, in proportion to the number of negative feedback mechanisms that can absorb or counteract the impact of external variables, particularly on a short-term basis. But over the longer term, complex, "steep-sloped" systems are not stable (for similar views, based on different arguments, see May 1977 and Rappaport 1978). The very multiplicity of systemic components increases the probability of a chance concatenation of negative inputs. For example, the unexpected coincidence of poor leadership, social pathology, external political stress, and environmental perturbation can trigger a catastrophic train of mutually reinforcing events (Fig. 7) that the system is unable to absorb.

A systemic model has a substantial advantage over the ontogenetic approach because it is nondeterministic and allows for chance. In fact, given the plethora of interlinked variables, transformations in a highly structured, vertical, and metastable system tend to be stochastic rather than teleological. It is a matter of probability, not of organismic inevitability, that cultural systems, like all human institutions, will eventually collapse, given a sufficiently long span of time.

A systemic, ecological model can be applied to more than functional or synchronic interpretation. The model proposed here includes synchronic components (Fig. 2) as well as tem-

poral or diachronic dimensions (Figs. 1 and 7). It can therefore accommodate a cyclic alternation between centuries when population and productivity increase and other intervals of demographic decline and political devolution. These periodicities are interpreted not as organic cycles of growth and senescence, but as readjustments among the processual variables that maintain the adaptive system.

Civilizations are indeed a type of adaptive system that can be objectively studied, as Adams (1978) has done in evaluating the impact of de facto, long-term or short-term maximization strategies for sustained adaptive equilibrium. Equally so, the discontinuities simulated by systemic collapse can be examined without recourse to traditional, subjective, and often moralistic interpretations such as "decadence."

The long course of Egyptian history exemplifies the dynamism of an adaptive system, characterized by a flexible but persistent social adjustment that was intimately linked to its floodplain environment. Major crises, external or internal, were successively overcome by reorganization of the political and economic superstructure, permitting new leases on national power or at least on economic productivity. Through all of this, the essential components of the sociocultural and environmental adaptation survived more or less intact until the nineteenth century A.D., even though the political, and ultimately also the ethnic, identity was transformed. In other words, Egyptian civilization did not "die" during times of political discontinuity. It survived as a flexible adaptive system, and the success of that adaptation is demonstrated in the fundamental continuities that link ancient and modern Egypt.

The adaptive system is of a far more basic character than the artistic and political achievement of a civilization. In this sense it is at the level of the adaptive system that processual studies can probably be implemented with the greatest profit.

References

Adams, R. M. 1978. Maximization, stability, and resilience in Mesopotamian society, settlement, and agriculture. *Proc. Amer. Phil. Soc.* 122:329–335.

Buckley, W. 1968. Society as a complex adaptive system. In *Modern Systems Research for the Behavioral Sciences,* ed. W. Buckley. Aldine, pp. 490–513.

Butzer, K. W. 1976. *Early Hydraulic Civilization in Egypt.* Univ. of Chicago Press.

——. 1980. Long-term Nile flood variation and political discontinuities in Pharaonic Egypt. In *The Causes and Consequences of Food Production in Africa,* eds. J. D. Clark and S. A. Brandt. Univ. of California Press.

——. In press. Rise and fall of Axum, Ethiopia: A geo-archaeological perspective. *Am. Antiquity.*

Chorley, R. J., and B. A. Kennedy. 1971. *Physical Geography: A Systems Approach.* Prentice-Hall.

Clarke, D. L. 1968. *Analytical Archaeology,* rev. by B. Chapman 1978. Columbia Univ. Press.

May, R. M. 1977. Thresholds and breakpoints in ecosystems with a multiplicity of stable states. *Nature* 269:471–477.

Rappaport, R. A. 1978. Maladaptation in social systems. In *The Evolution of Social Systems,* ed. J. Friedman and M. J. Rowlands. Univ. of Pittsburgh Press, pp. 49–72.

Wittfogel, Karl. 1957. *Oriental Despotism.* Yale Univ. Press.

"But enough about spiral galaxies, and the hundreds of billions of stars they contain. Let's dance."