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Long-Term Nile Flood Variation and Political Discontinuities in Pharaonic Egypt

KARL W. BUTZER

Egypt provides a unique physical, archaeological, and historical record of environment, technology, land use, settlement, and economic history. In effect, the Nile constitutes an oasis corridor through a thinly inhabited desert, providing a test-tube case for a society circumscribed by its environment and relatively isolated from external turmoil. Egyptian livelihood was closely linked to the waters of the river, further limiting the number of potential variables. Egyptian culture—defined by language, religion, and national consciousness—spanned some four thousand years, from late prehistoric well into Roman times. This gives an unusual time depth in which to evaluate ecological adjustments and response on various scales.

Subsistence-settlement systems of complex societies such as that of Pharaonic Egypt are in constant readjustment. They are also repeatedly modified and even transformed in response to external and internal variables. Endogenic factors in the case of Egypt include demographic trends, urbani-

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zation, social and economic stratification, agricultural intensification, and spontaneous as well as governmental expansion of agriculture into marginal environments (Butzer, 1976). Exogenic factors include human variables such as repeated invasions or sustained immigration by various peoples from the Western Desert, Nubia, or western Asia and from the open Mediterranean Sea; they also include the financial and cultural impacts of the New Kingdom imperium in Asia. Epidemics related to human or environmental factors are suggested by indirect evidence, e.g., the catastrophic plague introduced to Anatolia by Egyptian prisoners of war ca. 1325 B.C. (Aldred, 1975), as well as by allegorical references in Exodus. Last but not least, pressures were exerted at the core of the human ecosystem by forces from the non-human environment, primarily reflecting climatic variability within the monsoonal rainfall belt of eastern Africa (Butzer, 1979, 1980b). The critical continuing adjustments of the agricultural system to the vicissitudes of the Nile constitute the most fundamental and most dynamic aspect of Egyptian adaptation.

In an earlier monograph this writer (1976) emphasized the continuities in Egyptian hydraulic agriculture. The present paper focuses on the discontinuities, namely, flood variation and the vulnerability of Egyptian irrigation agriculture in Pharaonic times. The potential role of environmental stress in the historical discontinuities of Egypt is outlined, but the equally important social and political processes that marked these times of turmoil can only be hinted at in a brief paper such as this. It therefore bears emphasis that the present purpose is to explore the potential co-agency of environmental variables in the historical ensemble. There are two reasons for emphasizing an ecological perspective. First, the rich corpus of historical information from Egypt has yet to be critically reviewed from such a vantage point. A number of Egyptologists tend to regard their primary source literature as metaphorical; the only "real" events were politicomilitary, and even these are considered suspect unless they are corroborated in Asiatic archives or archaeology. Second, the Egyptian case provides an unusual opportunity for examining the role of economic limiting conditions in a complex human ecosystem.

Pharaoh and the Nile Floods

To the ancient Egyptians the Nile represented the source of life, the cosmic order, and creation itself. The annual flood reenacted creation, with the Primeval Hill rising above the receding primordial waters. The first dry land emerging from the inundation promised fresh life in the new agricultural year (J. A. Wilson, 1946). The cosmic order was identified with the cyclic, repetitive nature of events, e.g., the Nile and solar and lunar cycles. Osiris came to personify this fundamental concept of rebirth, growth, and death. The Pharaoh, by extension, was believed to cause the life-giving waters that brought fertility to Egypt and guaranteed the seasons (Frankfort, 1948: 52; Goedicke, 1960).

Pharaoh was depicted as the single representative of the entire community and sometimes described as the shepherd of his people. He was both god and man, the sole source of authority, yet Egypt was not an effectively authoritarian state. From at least the Thirteenth Dynasty (1784–1668 B.C.),[1] a vizier was responsible for actual administration, but the detailed implementation of central authority is not clear (Helck, 1954: 134ff.; 1975c). In earliest times, such direct administration may have been restricted to the royal properties scattered throughout the country (Helck, 1975a) and to such aspects as external defense and religious cult. As late as Ninetjer (ca. 2928–2884 B.C.), tribute appears to have been collected directly during periodic royal visitations to the provinces, and a complex system of taxation first began under Snefru (see Helck, 1975b). By the Sixth Dynasty (ca.

1. The chronology used in this paper is based on an evaluation of the radiocarbon dates (see Long, 1976, calibrated with reference to Damon et al., 1974) for the First and Second Dynasties (ca. 3170–2760 B.C.), K. Baer (n.d.) for the Old and Middle Kingdoms, and Wente and Van Siclen (1977) for the New Kingdom.

2405–2255 B.C.), the central administration appointed agents responsible for local or regional supervision of specific tasks or functions (Martin-Pardey, 1976), but such individuals served as intermediaries between the capital and the local communities rather than as components of a fully integrated bureaucratic hierarchy administering all phases of national activity.

Next to nothing is known about the emergence of artificial irrigation during late prehistoric times. The first document is the ceremonial breaching of the canal by the prehistoric Scorpion King (Butzer, 1976: 20–21), probably dating ca. 3200 B.C. Somewhat later, instances of royal canal-digging as well as tax exemption of a complex, if local, irrigation network are recorded in several Sixth Dynasty texts (Dunham, 1938; Goedicke, 1967: 72; Butzer, 1976: 45–47; Endesfelder, 1979), and an elaborate Fourth Dynasty (ca. 2680–2545 B.C.) masonry dam is preserved in one desert valley (G. W. Murray, 1947).

Flood basins would have operated as autonomous units, since they were impossible to interlink without highly elaborate technology and since, by drawing water directly from the Nile, they were unaffected by patterns of water-use upstream (see Butzer, 1976: 42–43). No regular or national appointment for irrigation and no related bureaucracy can be inferred from among almost 2,000 titles of the Old Kingdom (ca. 2760–2225 B.C.) (see K. Baer, 1960). The early record of canal-digging therefore suggests government support for expansion of artificial irrigation rather than an attempt to centralize irrigation administration; as late as 2000 B.C., the Hekanakht letters suggest that half of the valley floodplain was still traditionally used as unimproved pasture or fallow (K. Baer, 1963).

Irrigation of natural or artificial flood basins continued to be organized at the local level during the First Intermediate Period (ca. 2225–2035 B.C.), when provincial governors were first on record to cut several canals (Schenkel, 1965, 1978; Endesfelder, 1979). Middle Kingdom (2035–1668 B.C.) viziers were responsible for delegating orders for canal-digging nationwide (Endesfelder, 1979; Helck, 1975c), and during the New Kingdom (1570–1070 B.C.) new projects and possibly also maintenance were at times entrusted to ad hoc royal appointees, although irrigation management was a local matter, judging by the handful of exclusively low-echelon officeholders on record (Endesfelder, 1979). Even so, Papyrus Wilbour (ca. 1141 B.C.) suggests that large segments of Middle Egypt were used preeminently for pastoral activities (O'Connor, 1972), implying that the irrigation network was still incomplete (Butzer, 1976: 102–103).

Competition for water was never an issue in free-flooding alluvial basins (Butzer, 1976: 109), which obviated the need for meticulous governmental regulation. Except for "new lands" in the Faiyum, the Delta, and Middle Egypt, there is no evidence of a governmental farm policy keeping the rural sector gainfully employed or distributing land, seed, and tools. Instead, community affairs, including irrigation and flood control, continued to be organized at the grassroots level by *corvée* (forced labor) under the direction of village headmen, who owed their prestige to merit as much as to wealth and who acted as first among equals. This situation persisted well into the nineteenth century A.D. (see Willcocks, 1904: 71; G. Baer, 1969: chap. 2). Government seems to have been primarily interested in agriculture as a tax base—i.e., as an end-product—contributing little to its direct organization or maintenance. Agricultural productivity, although influenced by public order and security and responsive to new technologies, was primarily a response to the Nile floods. The health of the overall economic system, overwhelmingly dependent on agriculture, was consequently controlled as much by environmental as by human variables. Ultimately, the central government was weak when the national economy was weak, although a weak government could equally well lead to a weak economy.

Limitations to Traditional Irrigation Agriculture

Spatially, the ancient Egyptians viewed their land as a flat plain of fertile alluvial soil (Black Land), sharply demarcated from a rim of mountainous desert (Red Land) inhabited by foreign peoples. Equally important was the differential productivity due to a relief variation of 1 to 3 m within the

alluvial lands (Butzer, 1976: 15–18). (1) High levee topography along river banks provided good settlement sites but less fertile soils which could generally be cultivated only with lift irrigation. Tree crops and vegetable gardens were located here. (2) Higher parts of flood basins, next to the levees, experienced deficient water during low flood years and may not have been planted regularly. (3) Intermediate sectors of flood basins had both adequate water and drainage and a rich annual increment of fresh silt. These were the prime areas for cultivation of the single annual crop of barley, emmer wheat, beans, chickpeas, and other vegetables (Darby et al., 1977). (4) The lowest parts of flood basins had excessive water during good flood years, probably experienced long periods of fallow, and were primarily used for seasonal pasture. (5) Floodplain backswamps, cut-off channels, and delta-fringe marshland were all permanently waterlogged and used for fowling and grazing. Finally, (6) the Nile channel and its distributaries were rich in fish and waterfowl, the former providing the major source of animal protein for the common people.

Egyptian cultivation was implemented by wooden hoe or plow and flint or metal-tipped adzes. Seeds were broadcast on freshly turned soil that was broken down with hoes and wooden mallets; the seeds were then trampled into the soil by herds of driven animals.

When the natural system of irrigation was replaced by artificial basin irrigation (Butzer, 1976: 18–20), the major difference was deliberate control of water ingress and egress from the flood basins by means of short canals and temporary cuts (or mud-brick gates: see Schenkel, 1965: 71), by strengthening natural riverbank levees to form longitudinal dikes and, eventually, by subdivision of natural basins by transverse dikes. Lift irrigation (see Butzer, 1976: 41–51) was initially limited to horticulture by manual lifting of water, sometimes aided by shoulder yokes with two suspended buckets. The pole-and-lever device (*shaduf*) is first verified in Mesopotamia on an Akkadian cylinder seal (Salonen, 1968: pl. IV.4), ca. 2370–2200 B.C. It was only introduced to Egypt after 1500 B.C., and subsequently aided small-scale irrigation from wells or watercourses during low water. The waterwheel (*saqiya*), essential for large-scale and continuous-lift irrigation, was also of Mesopotamian origin and unknown in Egypt prior to 300 B.C. Pharaonic irrigation was then little more than a controlled version of natural basin irrigation, whereby mediocre floods could be extended somewhat and exceptionally high floods restrained slightly. There was no opportunity for more than one crop in the course of the normal rhythm of the flood season.

The traditional annual cycle included three main components: (1) Flood season or "autumn" (beginning early August in the south, terminating mid-November in the north), with inundation of basins by a variable water depth averaging 1.5 m in the fields for a duration of 6 to 10 weeks (Willcocks and Craig, 1913: 305–306); (2) Post-Flood season or "winter" (mid-November to mid-March), with high soil moisture and high water-table, mild temperatures, and low evaporation, ideal for sowing and growing of crops; (3) Pre-Flood season or "summer" (mid-March to mid-August), with dry soils, low water-levels, high temperatures, and periodic desiccating winds, so that any cultivation would require lift irrigation—traditionally limited to small garden plots—with extensive grazing elsewhere.

The flood cycle was characterized by short-term variability, i.e., year-to-year fluctuations in flood-crest elevation and flood duration. Low or short floods reduced the wetted area, the degree of soil saturation, and the amount of fertile silt deposited, but increased the salt concentration of waters reaching fields along the desert margins (Butzer, 1976: 52–54). This all reduced cultivated acreage as well as unit productivity. The flood crest of A.D. 1877 was 2 m below average and precluded cultivation of 35 percent of the valley alluvium (see Willcocks and Craig, 1913: table 176). Unusually high or persistent floods favored plant parasites in the soil, while the waterlogging retarded planting, with the harvest delayed into the parching Pre-Flood season (Willcocks and Craig, 1913: 304). Exceptionally high floods could raze settlements, favor epidemic disease, destroy food stores and livestock, endanger seed stocks, and sweep away major transverse dikes (see Willcocks, 1904: 71; Ball, 1939: 231–232) that had required at least one and often several years to construct. Overall variability

created significant year-to-year fluctuations of food supply, despite the general predictability and reliability of Nile floods.

Increased recurrence of exceptionally low or high floods (or both), from several times a century to several times a decade, could have had great impact on traditional irrigation agriculture. Long-term trends, over several generations, to overall lower or higher flood levels probably had equally important repercussions, eventually favoring geomorphic readjustments. Lower floods may eventually have favored channel incision and a floodplain of reduced size, with a lower water-table and receiving less nitrogen-rich silt; parts of the floodplain would have been incultivable, and salinization as well as dune invasion could have affected outlying areas. A systematic increase in flood height would have expanded the inundated realm and augmented fertility, but irrigation maintenance would have been more difficult, due to frequent levee-breaching and rapid siltation of canals.

The historical flood records from Egypt and geomorphic data from the upper Nile basin verify repeated changes in flood levels, in terms both of net trends and recurrence intervals (see Butzer, 1976: 27–33, 51–54). Although periodic channel incision is difficult to prove without elaborate fieldwork, episodes of reduced channel sinuosity are apparent in the surviving floodplain topography and, together with the tantalizingly incomplete record of rapid sediment changes from well profiles (Butzer, 1976: 15–16; Attia, 1954), suggest intervals of incision during the historical era. At the same time, various Nilometers between Aswan and the Delta refer to two successive datum levels that, in conjunction with flood reports from different periods, show an overall building-up of the Nile floodplain since the First Dynasty (Jaritz and Bietak, 1977).

Evidence for Long-Term Variation 3000 to 1000 B.C

ANOMALY I

Throughout the southern Sahara and the upper Nile drainage, hydrological trends were negative early during the third millennium, with a period of relatively moist conditions terminating 2850 ± 100 B.C. (calibrated after Damon et al., 1974; for data, see Butzer, 1976: 30–33; 1979; 1980a; 1980b). In Egypt, sixty-three annual records of Nile flood-levels are available between 3000 and 2500 B.C., and they show a net 1 m decline of flood level between the late First and mid-Second Dynasties, i.e., ca. 3000–2900 B.C. (see B. Bell, 1970; Helck, 1966). In terms of nineteenth-century criteria, 1 m implies a thirty percent reduction in discharge, comparable to the deviation of 1877, the lowest flood-year in the period A.D. 1869–1903, from that thirty-five-year mean. Year 14 of Ninetjer (ca. 2913 B.C.) experienced one of the lowest floods ever. These points require no elaboration.

ANOMALY II

Sub-Saharan lake levels remained very low until 1950 ± 50 B.C. Old Kingdom records indicate a leveling-off of the flood decline between 2900 and 2500 B.C. (B. Bell, 1970), after which we unfortunately lack information. There is no contemporary physical evidence available from Egypt proper, but a major advance of desert dunes into the western floodplain of Middle Egypt appears to have begun during this general time-range (Butzer, 1959b). Consequently, precision on Anomaly II must be derived from historical sources.

A seven-year span of low Niles is alleged for the reign of Djoser (culminating in Year 18, ca. 2720 B.C.) by the so-called Famine Stela, a Ptolemaic work based on an Old Kingdom original, probably "edited" for political purposes (Wildung, 1969: 85–91). Equally suggestive but difficult to evaluate is the sizable body of First Intermediate Period texts that record famines related to low Niles (Vandier, 1936; Schenkel, 1965; 1978: 29–51; B. Bell, 1971; Saffirio, 1975; Guglielmi, 1977). These date between the times of the Upper Egyptian governor Ankhtifi (ca. 2210–2185 B.C.) and those of the Middle Egyptian governor Ameni (ca. 1925–1895 B.C.) (K. Baer, n.d.).

The events chronicled for Ankhtifi are place- and incident-specific and consequently inspire considerable confidence. Self-congratulatory texts

about feeding the hungry do appear in the earlier, royal Pyramid Texts, also once in direct reference to catastrophic famine and Nile failure ("hunger on this sand bank of Apophis [= the underworld serpent]": see Schenkel, 1965: 54), and allusions to dust storms. As B. Bell (1971) argues, this association leaves no doubt as to the intended meaning. But it is no simple copy, because a specific event is described ("all Upper Egypt was dying of hunger": Schenkel, 1965: 54) and related to cannibalism ("everyone ate his children one after the other": ibid.), an outrageous situation for Egyptian sensitivities, although patently exaggerated, and the first document of its kind. The Ankhtifi inscriptions can be faulted in terms of details of authenticity and trustworthiness but, by comparison with other ancient Near Eastern documents, their basic content is unambiguous, specific, and acceptable as a record of catastrophic Nile failure.

The second source on Nile failures is the unquestionably authentic collection of private letters by Hekanakht dating from 2002 B.C. (K. Baer, 1963). Writing to his family from one of his estates, the author describes the impact of an ongoing nationwide famine due to poor Nile flooding and his own efforts to conserve food by doling out half-rations, and notes that "they have begun to eat people here" (ibid.: 27–28).

The same confidence cannot be applied to other biographical famine inscriptions, which are highly conventional and generally date between Ankhtifi and Hekanakht. Whether or not the historicity of these other documents is accepted, an unbiased reader must be impressed by the lingering image of sociopolitical trauma illustrated in several composite or derivative works of substantially later date, each of which implies direct links between environmental and social disasters. These include the Admonitions of Ipuwer and the Prophecies of Neferti (see Fecht, 1972; Simpson, 1973; Spiegel, 1975; and Butzer, 1976: 54; contra Lichtheim, 1973: 10). The latter is a political tract dating from the accession of Amenemhet I, 1991 B.C. Previous trauma is clearly expressed by

> I will speak of what is before my eyes. . . . The river of Egypt is dry and men cross the water on foot; men will seek water for ships in order to navigate [the river], for . . . the place of water has become a riverbank. (Simpson, 1973: 236–237)

In the present writer's view, these historical documents make a reasonable case for at least two episodes of catastrophic Nile failure ca. 2200 and 2002 B.C.

ANOMALY III

Wet conditions were abruptly reestablished in East Africa ca. 1970 B.C. Lake Rudolf was soon 75 m deeper and overflowed into the Nile system (Butzer, 1980b) and the White Nile was 2–3 m higher than at present, with a discharge 10 times greater than now (L. Berry, 1960; Williams and Adamson, 1974). In the cataracts of Sudanese Nubia there are at least twenty-seven inscriptions dating 1840–1770 B.C. that record floods 8–11 m higher than those of the present (B. Bell, 1975). These imply flood volumes three or four times greater than the maximum floods since A.D. 1869 and probably resulted in crests 2–4 m higher than normal in the northern Nile Valley, i.e., at least twice the basin-water depth of a normal year and probably comparable to the catastrophic floods of A.D. 1818–1819. Such an erratic, "wild" Nile in Egypt, with a recurrence interval of about one year in three, is not entirely unprecedented; it occurred over several centuries ca. 12,000 years ago (Butzer, 1980a). Whether catastrophically high Nile floods were common after 1770 B.C. is unknown, but an unusually high inundation is recorded ca. 1695 B.C. (Habachi, 1974).

ANOMALY IV

Lake levels fell dramatically in East Africa ca. 1260 ± 50 B.C. In Nubia, agriculture ceased almost entirely after the end of the reign of Ramesses II (i.e., after 1212 B.C.) (Trigger, 1965: 112–114). At Aksha, where floods were 1 m higher than today during Ramesses II's time, dunes spread over the floodplain and the lack of flooding allowed thick salt efflorescences to build up; cultivation only resumed ca. 300 B.C. (Heinzelin, 1964). In the Delta,

discharge along the peripheral Pelusiac Nile distributary declined so much that the Ramessid residence of Avaris (Pi-Ramesse) was abandoned in favor of Tanis, on the Tanitic branch, shortly after 1200 B.C. (Bietak, 1975: 99–109). Here, once again, the physical and archaeological evidence is unequivocal, finding further support in the historical evidence discussed below.

Political Discontinuities and Nile Variation

The political history of Egypt is 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 apexed in an episode of strong central government, followed by a long period of decline. The First Dynasty, ca. 3170–2970 B.C., represents another such culmination point of a less clearly delineated protohistoric development. It appears that each phase of political devolution was accompanied by economic deterioration and at least temporary demographic setbacks. Political and economic decline coincided temporarily with long-term negative Nile behavior.

The four periods of decline are: (1) the Second Dynasty (ca. 2970–2760 B.C.), coincident with Anomaly I; (2) the Seventh and Eighth dynasties and the First Intermediate Period (ca. 2250–2035 B.C.), coincident with Anomaly II; (3) the Thirteenth Dynasty and Second Intermediate Period (1784–1560 B.C.), following Anomaly III; and (4) the Twentieth Dynasty, following the food riots of 1153 B.C. and the assassination of Ramesses III in 1151 B.C., coincident with Anomaly IV. Some aspects of each of these episodes suggest potential socioeconomic repercussions to environmental stress.

ANOMALY I

The Second Dynasty was a time of impoverishment and political confusion. The archaeological record remains ambiguous as long as the possibility exists that some Second Dynasty tombs are unidentified or undiscovered. Nonetheless, trade communications with the Near East were significantly reduced during this period and few examples of Palestinian import wares are known (Kantor, 1965). By comparison, the wealthy First Dynasty Pharaohs had magazines filled with import goods, and the resumption of international trade at the very end of the Second Dynasty is conspicuous in the archaeological record. The indisputable dynastic confusion during the Second Dynasty appears to have been heralded by a civil war during Year 13 of Ninetjer (Emery, 1961: 93). The sequence and number of the next six or so kings (Weneg, Sened, Nubnefer, Neferkasokar, Peribsen, Sekhemib) are uncertain, over a timespan of at least 43 and as much as 148 years (K. Baer, n.d.; Helck, 1956, 1974), with the calibrated radiocarbon dates (Long, 1976; see Damon et al., 1974) strongly favoring the higher figure. Records of all kinds are very scarce (Kaplony, 1965) and, significantly, no tombs are known from these kings except for the last, Sekhemib, whose burial place was not in Saqqara, Lower Egypt, but Abydos, Upper Egypt. The final ruler of the Second Dynasty, Khasekhemwy (ca. 2787–2760 B.C.), had his power base in the far south and carried only the Upper Egyptian crown on his accession (K. Baer, n.d.). The dynasty barely survived, threatened by revolt or invasion in the north, until Khasekhemwy eventually conquered his opponents in a major campaign (Kaplony, 1975; Piccione, n.d.). Persistent civil unrest or, alternatively, flimsy construction and impoverishment are implicated in the unusual circumstances that the tombs of only four of some nine or ten Second Dynasty Pharaohs have been identified (or are identifiable) so far. Finally, it may be material that, as a general index of living conditions, mean life expectancy dropped from 36 years in late prehistoric times, when Nile floods were ample, to 30 years during historical times (Masali and Chiarelli, 1972), when overall floodplain ecology was readjusted to more modest floods and population pressure was substantially greater.

ANOMALY II

Central authority markedly declined during the Sixth Dynasty, with a futile attempt to reassert this

authority midway in the reign of Pepi II (ca. 2350–2260 B.C.) (K. Baer, 1960), after whose death the Old Kingdom disintegrated into regional principalities (O'Connor, 1974). An overall reduction in the size and opulence of funerary architecture, in the capital and in the provinces and among low- as well as high-echelon officials (Kanawati, 1977), documents a progressive and general economic decline during the later Sixth Dynasty. The ensuing lamentations of the First Intermediate Period causally link drought, starvation, anarchy, and political impotence. Food stores were plundered, the estates of the rich were dispossessed, and hordes of starving people roamed the countryside, threatening the foundations of the social order. The traditional Egyptian perception of the revolutionary trends of this era (Spiegel, 1975) is expressed in the admonitions of Ipuwer:

> Indeed, noblemen are in distress, while the poor man is full of joy. Every town says: "Let us suppress the powerful among us." . . . The children of princes are dashed against walls. . . . Public offices are opened and their inventories are taken away. . . . The laws of the council chamber are thrown out; indeed, men walk on them in the public places. . . . The King has been deposed by the rabble. . . . The King's storehouse is the common property of everyone, and the entire palace is without its revenues. (Simpson, 1973: 212–223)

Other textual elaborations of famine, abandoned farm lands, and dislocated people serve to illustrate the degree to which the agricultural system had lost its capacity to sustain previous levels of productivity, resulting in a mutual sharing of increased poverty. Food redistribution in times of need, as well as restoration of agricultural productivity, became key political virtues, and Ankhtifi prided himself on being the first ruler to distribute famine supplies (Schenkel, 1965: 54). The Old Kingdom temples did not store grain supplies for possible redistribution (Posener-Kriéger and Cenival, 1968), and during the famine years the governor Djehuti (ca. 2100 B.C.) was even obliged to find food to supply the temple of Amun in Thebes (Vandier, 1936: 109). In view of the national economic shortcomings apparent during the First Intermediate Period, it seems logical that the Twelfth Dynasty kings (1991–1784 B.C.) should have begun systematic development of the Faiyum, the first example of direct government involvement in the improvement of marginal or underutilized lands (Butzer, 1976: 36–38, 92–93; Arnold, 1977).

ANOMALY III

The last kings of Dynasty Twelve were weak, and the Thirteenth Dynasty Pharaohs (1784–1668 B.C.) reigned an average of only two years each; apparently a dynasty of viziers held real control, judging by the record of over sixty-five kings and only seven viziers (K. Baer, n.d.). The steady erosion of royal power may have resulted from a disastrous economy, although the records are mute except for one curious lamentation (Kadish, 1973). By about 1720—well before the Hyksos invasion of 1668 B.C.—national unity was being threatened by petty principalities in the Delta. The decline of the Middle Kingdom remains one of the most obscure aspects of Egyptian history, so that the potential significance of the aberrant flood record can be no more than conjectural.

ANOMALY IV

The increasing political impotence of the Twentieth Dynasty is closely linked to economic stress. The Pharaoh Merneptah was still able to provide the Hittites with grain during the famine of 1210 B.C. (Faulkner, 1975), but in his sixth year, 1176 B.C., Ramesses III found it appropriate to make offerings to the Nile at Gebel Silsila, to propitiate the river and seek good floods (Stern, 1873). In 1153 the food supply failed and the workmen of Deir el-Medina rioted; the best efforts of Ramesses III's vizier to meet the crisis turned up only a bare half of the wheat needed (Faulkner, 1975). Grain prices, with respect to non-food products, had increased rapidly after 1170 B.C., to eight times and occasionally twenty-four times the standard price; the highest inflation occurred about 1130 B.C., followed by stabilization ca. 1110 B.C. and a rapid drop in food prices 1100–1070 B.C.

(Černý, 1933; Janssen, 1975: 550–558). Evidently, wheat and barley, as well as vegetable oil, were in very short supply, in response to mediocre or poor Nile floods, and the temple granaries, so important since the fifteenth century B.C. (N. de G. Davies, 1929; Butzer, 1976: 88), were applied to private gain rather than community redistribution. A succession of trials of prominent and less prominent tomb-robbers spans the period from 1154 to after 1107 B.C., reflecting on government corruption but probably also on economic hardship. The cemeteries indicate widespread impoverishment and, possibly, a declining population (B. J. Kemp, pers. comm.). Royal power withered away until, at the end of the Twentieth Dynasty (1184–1070 B.C.), the priesthood disenfranchised Pharaoh as the provider of life and safeguard of the cosmic order, declaring him a simple agent of the supreme god Amun (Černý, 1975). It is tempting to interpret this change as a reflection of Pharaoh's failure to guarantee nature and thus the livelihood of Egypt.

These potential interrelationships between long-term environmental stress and political instability range from possible to probable, and at the very least, in all instances, the co-agency of other endogenic or exogenic forces is also part of the equation. The broader context for each anomaly can now be outlined.

ANOMALY I

Quarrels about the dynastic succession are already evident during the later First Dynasty and may have been a prelude to a long era of civil strife, possibly abetted by Libyans from outside the Nile ecosystem. The power of the late Predynastic and First Dynasty rulers appears to have increased fairly steadily until the death of Dewen (ca. 3025 B.C.), who had created a rudimentary bureaucracy. But almost 250 years of devolution followed before Khasekhemwy (ca. 2775 B.C.) was able to reunite the faltering nation. Sectionalism and an inadequate administrative structure may have been primarily at fault but do not explain the probable impoverishment of the country and limited Asiatic trade even before the possible revolt of Lower Egypt after the death of Ninetjer (ca. 2874 B.C.). It is therefore plausible that recurrent poor floods or Nile failures weakened the economy and created a periodic stress of disastrous proportions.

ANOMALY II

The Old Kingdom was in political and economic ascendancy from Khasekhemwy to the death of Cheops (ca. 2578 B.C.), and a strong, functional bureaucracy was created. But perpetual mortuary endowments were set up on an increasingly large scale, withdrawing prime agricultural lands and their produce from the revenue base to support tax-free mortuary cults (Helck, 1954). During the Fifth Dynasty (ca. 2545–2405 B.C.), the larger temples emerged as strong competitors for power, while during the mid-Sixth Dynasty the burgeoning aristocracy and upper-level bureaucracy acquired great wealth and, in part, began to create local power bases in the provinces. Thus more than two centuries of devolution preceded the political confusion that followed the death of Pepi II (ca. 2260 B.C.), which implies that Old Kingdom Egypt was hopelessly inefficient and in drastic need of socio-political reform. Political fragmentation preceded any Nile-related disasters, although these may have triggered the social unrest that ultimately led to a reassessment of traditional values. Here, again, one could argue that the case for the co-agency of environmental stress is plausible but not evidently necessary to explain the course of events.

ANOMALY III

Political ascendancy is evident with the reunification of Egypt in 2035 B.C.—despite further Nile calamities. During the Second Intermediate Period, foreign invaders, the Hyksos, took control of the Delta in 1668 B.C., but competing principalities had been set up thirty years earlier and political devolution was already apparent by the death of Amenemhet III (1794 B.C.). Why the Middle Kingdom collapsed is quite enigmatic, and recurrent, excessive high floods provide no more than a possible economic scenario.

ANOMALY IV

A new period of ascendancy began with the accession of Kamose in 1576 B.C., and major socioeconomic problems such as the growing wealth and power of the temple of Amun are patently obvious during Amenhotep III's superficially prosperous reign (1386–1349 B.C.). Ramesses II (1279–1212 B.C.) was able to delay devolution, but the real power of the Pharaoh was shrinking rapidly and corruption was rampant by the time of his death. Then, desperate struggles with major foreign invasions from land and sea shook Egypt to its roots in 1207 and 1177–1171 B.C., leading to the loss of the Asiatic empire and its monetary tribute. By the end of the century, Libyan marauders were terrorizing the countryside almost at will (Černý, 1975), while overtaxation exacerbated rural depopulation (Caminos, 1954: 389–395; 1977: 62–63, 78).

These circumstances would be adequate to explain the demise of the New Kingdom, but the significance of economic processes in the twelfth-century B.C. decline of Egypt is equally unassailable. The workers' strikes and food riots (at least six major incidents are recorded between 1153 and 1105 B.C.) are inescapably linked to the wild inflation of food prices coincident with the major, negative readjustment of Nile hydrology that forced the abandonment of the Nubian floodplain. Significantly, the loss of fiscal wealth after the destruction of Egypt's Asiatic empire in the 1170s should have led to a money, not food, shortage, and the desert gold-mines were subsequently abandoned long before they were exhausted, later kings restoring their productivity (see Gundlach, 1977a, 1977b). Furthermore, there is no correlation between the food-price spiral and either the episodes of civil war (ca. 1139 and 1089 B.C.) or the rural insecurity resulting from the Libyan infiltration after 1117 B.C. (see Černý, 1975). It is consequently highly probable that ecological stress and resulting economic deterioration were heavily implicated in the end of the New Kingdom, but as only one of several factors.

This final, lightly documented overview suggests that the major cyclic crises of Egyptian history cannot be fully explained by politically generated agrarian cycles of the type first postulated by Wittfogel (1938). Instead, one of the most consistent links in Egyptian historical trends is among water, agricultural productivity, and politicoeconomic strength. By the standards of Mesopotamian flood unpredictability or of rainfall unpredictability in many dry-farming regions of the Mediterranean Basin and southeastern Europe, Nilotic agriculture was reliable. But the simple winter-crop routine, the lack of effective lift-irrigation, and the sum of the historical insights show that this ecosystem was nonetheless fragile. It therefore becomes probable that aperiodic variability of the Nile floods had significant material consequences.

Stability and Change

The economic history of Egypt was closely dependent on the Nile and its behavior. Egypt was, after all, the gift of the river, and the river was for the cosmic order to control. Within the confined environment of a riverine oasis guaranteed by an exotic river and relatively isolated from foreign invaders, Egyptian culture evolved with unprecedented self-sufficiency and disdain for revolutionary change. Continuity and harmony—with the past, with the cosmic forces, and with the cyclic natural order—were keystones of Egyptian society. But this apparent stability was more a dynamic equilibrium in which a multitude of short- and long-term adjustments in extractive tasks and exchange patterns were made without substantially changing the basic configurations of the adaptation. Ultimately, only the spirit of the adaptation remained the same, since new domesticates, technologies, and ideas had been incorporated to create a far more complex and effective adaptive system (see Butzer, 1976: chap. 7).

Complex cultural systems are to some extent buffered from environmental variables by multiple "layers" of technology, social organization, and exchange networking. Their adaptive strategies emphasize stability—maintenance of a set of socioeconomic priorities, cultural norms, and value systems. However, interpreted in terms of their own cognitive universe, environmental catastrophes to the Ancient Egyptians or to most other complex societies were interruptions in the normal stream of

events. But the system that shields both the society and the individual also suffers from an innate lack of pliancy. The instability threshold of complex cultural systems tends to be high in proportion to the number of negative-feedback mechanisms. This very multiplicity of components increases the probability of a chance concatenation of negative inputs. For example, the unexpected coincidence of poor leadership, external political stress, and environmental perturbation can trigger a catastrophic train of mutually reinforcing events which the system cannot absorb.

Viewed over a span of five millennia, Egypt, as well as Mesopotamia (see R. McC. Adams, 1978), exemplifies the inherent diachronic dynamism of an adaptive system characterized by a particular social and natural environment. The historical trajectory is marked by cyclic alternation between centuries when population and productivity increased, in apparent response to effective hierarchical control, and other centuries characterized by demographic decline and political devolution. Periodic minor and diverse crises were overcome by temporary structural shifts, whereas major crises led to reorganization of the political and economic superstructure, leaving intact the basic environmental and sociocultural components of the infrastructure. Consequently, although the social and political identities of these floodplains have repeatedly changed since the time of Old Kingdom Egypt and Sumer, the fundamental adaptive system survived in Egypt and Iraq well into the nineteenth century.

It appears, then, that elaborate cultural systems enjoy centuries of adaptive equilibrium—with or without sustained growth—followed by discontinuities. Such discontinuities have been downplayed in the organic or ontogenetic paradigms fashionable in historical and archaeological research (Butzer, 1980c), but such breaks may well be critical in understanding cultural systems. They appear to be marked by reevaluation of adaptive strategies, while the cultural system undergoes structural elaboration or changes among its fundamental components with or without a transformation of identity. In the long-range view, elaborate cultural systems are dynamic rather than stable, since structural changes are repeatedly required to ensure viability or even survival. Such systems have far too many variables for their trajectories to be predicted by a deterministic equation. On the other hand, such a plethora of interlinked variables can lead to processes and events that are to some degree stochastic. Patterns of behavior and adaptive responses should therefore be amenable to statistical evaluation in probabilistic terms. But statistical probabilities or situations are of little more than theoretical interest in the social sciences (G. Cowgill, pers. comm.), where primary concern focuses on the individual trajectory.

The Egyptian case outlined in this paper suggests strongly that environmental stress is a real—in fact, a powerful—variable among the many that make probabilistic projections difficult if not impossible. It further suggests a need for a methodology to investigate such stress in the archaeological or historical record, in particular, the identification of stress points and potential thresholds, and their systemic evaluation.