Perspectives on Irrigation Civilization in Pharaonic Egypt

by

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Irrigation agriculture provided the economic base for the first civilizations in the Near East. Most alluvial soils in subtropical and tropical environments are naturally fertile and agriculturally productive where water is adequate. The added element of labor and technology—implied in the concept of irrigation—optimizes the distribution of available water to improve median crop yields and to reduce their annual variablility. The potential yields of such an intensive form of land use greatly increase carrying capacity and may allow human populations to remain closer to such carrying capacities. Given the primitive communication systems inherent to early civilizations, a ring of high-productivity lands could support large populations within reasonable distance of high-order central places. It is therefore not surprising that the archeological and historical records suggest a more than casual coincidence between foci of irrigation farming, urban centers, and evidence for complex economic and social stratification.

The apparent relationships between irrigation farming and socio-political forms has long intrigued historians of one generation, and social scientists of another. One classic view was articulated by V. Gordon Childe (1929, and later), who argued that irrigation provided the agricultural surplus essential to economically-complex societies, thereby creating opportunity for the development of vertically-structured, urban civilizations. Another, related hypothesis was explicated by Karl Wittfogel (1938, and later), who linked "hydraulic" civilizations with his socio-political model of a highly-organized peasantry, exploited by an absolute, bureaucratic, and centralized state ("oriental despotism"). These notions have provoked the growth of a prodigious body of secondary, discoursive literature as well as several fresh archeological or historical analyses at various scales. Yet, the ecological framework of an ancient hydraulic society has never been systematically examined. Any ecological perspectives to emerge in these general discussions have considered too few variables or have been patently erroneous, and their significance has accordingly been dismissed or ignored.

This is unfortunate, since the basic "procedures" of a cultural ecology were outlined over two decades ago by Steward (1954). Their basic intent has become central to much of the best archeological theory, but their implementation has proved elusive, in the main part because the data base is or appears to be inadequate. I have long suspected that the comparative lack of success in implementing a more effective ecological approach in past contexts has been symptomatic of disciplinary isolation and ineffectual methodologies. An ecological framework should focus on three independent variables, on or through which the fourth variable is modelled. These independent variables are environment, technology, and population (including settlement and demography). The dependent variable in this equation is social organization and differentiation. Interrelationships between nature and culture cannot be deciphered without a sophisticated comprehension of the environment, nor without reasonably good information on technology and population. Such relationships are rarely appreciated by the many social scientists who concern themselves exclusively with the dependent variable of the above equation.

The emergence and evolution of an hydraulic civilization in the Nile Valley provide a unique possibility to explore this critical matter of cultural ecology. It is quite pertinent to Childe and Wittfogel, and to what has been written and argued since. Here there is an unusual wealth of cultural and environmental data that span five millennia of historical time and an even longer range of prehistory. My own interests in the natural and cultural landscape complex of Egypt have profited from repeated research efforts on Egypt, interrupted by extended studies in Spain, Ethiopia, and South Africa dealing with both similar and different time periods. Each time I returned to the Egyptian materials with more experience and broader perspectives. The result has been a systematic attempt to analyze the archeological and historical record of environment, technology, settlement, and land use in ancient Egypt. The data are at once imperfect and exciting, and are more fully documented in the original publication (Butzer 1976). The present paper outlines the basic arguments and re-examines some existing hypotheses.

The Nile floodplain and delta represent free-draining, seasonally-inundated alluvial surfaces. In such a model, exemplified by the Nile or the Mississippi, the river generally remains within its channel but, in the case of the Nile, between late summer and early autumn, it spills out to flood the low-lying basins to an average depth of 1.5 m, laying down a thin increment of fertile silt and clay before the waters drain back naturally into the river, or evaporate from the floodplain. The highest alluvial ground follows the river channel, or that of its major branches, in the form of silt berms or natural levees that are topped by flood waters only briefly during 1-in-10-year episodes of peak discharge. The flood basins are subdivided by such levees, and further demarcated by the rapid rise of land at the desert margins. Such natural basins vary in size from a few square kilometers to over a hundred, being largest where the alluvial valley is widest and where the river is farthest away from one desert edge. The flood waters enter by low points in the levees, often along small but defined diverging channels, to drain back into the Nile, as the floods recede, by a network of gathering streams. Flood stage comes earliest in the south, latest in the north, with the flood basins filling for an average of 4 to 6 weeks, and then draining except for small, residual water bodies or marsh in the low-lying backswamps.

The hydrology of the Nile River is remarkably predictable by the standards of other river systems. The upper basin taps two major climatic provinces for its water: the summer monsoon in Ethiopia and the southern Sudan, and the double, equinoctial rainy season of Uganda and Tanzania. The blending of these water supplies south of the axis of the Sahara, and the specific hydrographic pattern of river basins at different latitudes, provides a comparatively balanced and reliable flood regime between August and November, followed by a long low-water season in which the river is increasingly sluggish, but essentially never fails. The basic seasons can be easily recognized according to the state of the river–its minute fluctuations of level and persistent trends, its color and condition. The temporal framework thus provided is far more explicit and foolproof than any available elsewhere on the basis of hydrographic or climatic seasons, and would have been recognized long before the invention of an astronomical calendar.

Given these physical premises, which have persisted with little change since at least 25,000 years ago, the biota of the Nile flood-plain received a new lease on life each year as the waters began to rise. Such a hydrological system, combined with the specific topographic arrangement within a "convex" floodplain, provided a natural mechanism of irrigation and drainage. Along other, comparable African rivers it supports a fringing forest on the banks and levees, a grassy savanna on the floors of the flood basins, and sedge, reed and papyrus marsh or lotus-studded ponds in the backswamps, channel cut-offs, and in coastal proximity. The levees provide suitable settlement sites, while the basin floors can be cultivated as the flood waters recede, or generally used for grazing until the next flood. The excellent record of Upper Paleolithic and Epi-Paleolithic settlement shows a decided preference for riverbank sites and there was no conceivable need to "colonize" the alluvial lands at a comparatively late date, by first draining the flood basins and clearing any hypothetical jungle-like thickets.

It has, then, been widely overlooked that the Nile flood basins are free-draining and naturally irrigated. Upper Paleolithic groups harvested a variety of plant foods and successfully hunted a broad spectrum of aquatic, woodland, savanna, and desert game from encampments located on the river banks. Equally so, Neolithic groups since about 5000 B.C. grazed their herds quite freely and, as the floods receded, planted fields for a single crop that grew to maturity on the basis of stored soil moisture and a relatively high groundwater table. Even in late Pleistocene times, rainfall in Egypt proper would have been inadequate for agriculture away from the waters of the Nile. But natural irrigation was always available, so that *artificial* irrigation was supplementary rather than essential for agricultural subsistence on the floodplain. The purpose of artificial irrigation in the Nile Valley was to increase crop acreage and to help equalize year-to-year productivity versus relatively small but ecologically significant fluctuations in flood level and persistance.

The technology and organization of Egyptian irrigation in Pharaonic times was consequently geared to a specific environmental system and intended to extend and intensify the agricultural base. This was implemented in the form of traditional basin irrigation, such as persisted in Upper Egypt until late in the 19th century A.D. Modern analogs suggest several logical steps for rudimentary, artificial irrigation. Deliberate flooding and draining of natural basins, by breaches or more elaborate sluice gates in the natural levees, is the first and most obvious procedure. Such controlled irrigation would be easiest in the smaller flood basins of southern Egypt and, further north, primarily along the narrow alluvial strip east of the river. Eventually, the natural levees would be strengthened and equalized by superimposition of longitudinal dikes. Ultimately the larger flood basins would be subdivided into more manageable units by transverse dikes. Development of such an irrigation system, particularly in the larger basins, required a massive input of labor and large-scale community cooperation much like it did a century ago. This applied both to the regular opening and closing of the dikes, particularly at times of exceptionally high floods, as well as to the initial construction and maintenance of artificial dikes. Canals, except for ditches, cut through dikes, were probably unknown at first, but by Ist Dynasty times (ca. 3050 B.C.) networks of small canals served to distribute water to the fields below sluice gates. However, large-scale canalization was only implemented in Egypt during the 19th century A.D. Lift irrigation, other than manually–by single bucket or by a shoulder-yoke to support two buckets–was not practiced until the later 18th Dynasty (ca. 1400 B.C.), when the lever or shaduf was introduced. The far more effective waterwheel or saqiya diffused through Egypt much later, during the last 3 centuries B.C. In effect, lift irrigation was only utilized on a localized, horticultural basis in Pharaonic Egypt, serving to water vegetable, fruit, and ornamental gardens. Summer garden crops, or cultivation of the higher-lying levees, were impossible without lift irrigation, and even in Ptolemaic times, when summer staples such as sorghum were introduced, the limitations of natural fertility precluded more than one crop per year on any one plot of land.

The prevalent image of intensive and sophisticated irrigation in Pharaonic Egypt is, then, misleading. During the early Middle Kingdom, ca. 2000 B.C., it appears that pasture and cultivation were practiced on roughly equal areas of the Nile floodplain, while a millennium earlier it is probable that hunting was still important in extensive areas of unutilized "wilderness."

To what extent was this progressive development of Egypt centrally directed or organized? The mace-head of the Scorpion King, ca. 3100 B.C., shows Pharaoh ceremonially breaching a dike, to inaugurate the flood season–as interpreted in analogy to early 19th century custom. There are a number of 6th Dynasty allusions to the cutting of canals by the king, but large-scale development is first suggested for the 12th Dynasty (1991-1786 B.C.), which "opened up" the Faiyum Depression, a low-lying marshy adjunct to the Nile Valley with a central lake. Expansion of the cultivated lands into the northern half of the Nile Delta was apparently favored by the Ramessids (1320-1070 B.C.), the Saite Dynasty (663-525 B.C.), and particularly by the Ptolemies (323-30 B.C.), who also organized a systematic expansion of cultivation in the Faiyum, constructing a radial irrigation network similar to those prevalent in ancient Mesopotamia.

Unlike the entrepreneurial and mercantile administration of the Ptolemies, the agricultural policies of the Egyptian Pharaohs seem to have been mainly directed towards administration of the scattered royal domains and the rewarding of retainers, veterans, and temples with land grants. This did lead to demonstrable founding of new settlements or to the intensification of productivity in the Delta and Faiyum, and to some degree in more thinly-settled areas upvalley. But there never was a centrally-organized irrigation system, nor a formal bureaucracy to deal with irrigation. In fact, water legislation is conspicuously absent among the written records relevant to the Nile Valley (as opposed to the Libyan Desert oases and Syria), indicating that irrigation procedure and water rights were already firmly committed to oral tradition in late prehistoric times, requiring no subsequent redefinition. Despite the symbolic identificaiton of Pharaoh with the annual flood cycle from the earliest times, irrigation was implemented at the community level, by the input of all able-bodied men, just as it was in the 19th century A.D. Each natural flood basin formed a logical unit of social organization, for general maintenance and effective interdigitation of the artificial subbasins. As the settlement record shows, such basins were commonly linked to central places positioned at intervals along the length of the Nile or its major branches. Several larger and a number of smaller basins of this type constituted the basic polities, or nomes, of Egypt. The political infrastructure was therefore anchored—however indirectly—within an ecological framework and with reference to scale components of the fundamental social organization. In contrast to radial systems, where water inputs are artificially regulated at each distributional node, there was no competition for water between individual flood basins, each of which had direct access to the Nile and was unaffected by water use or regulation upstream.

The distribution of settlements in Pharaonic Egypt provides clear evidence of population gradients and centers of concentration. Densities were markedly greater in the narrower floodplain segments in the south, and in the far north, near Memphis. It can be argued that intensive utilization of the intervening section of broader floodplain was rendered difficult by the great size of the natural flood basins. These would have required massive labor to bring under control, and there is evidence for a persistence of extensive as opposed to intensive land use in these underdeveloped nomes until at least the 12th century B.C. It is also possible that internal colonization was inhibited by a nome structure originally based on tribal subdivisions among the Nile flood basins. Only in the New Kingdom did government resettlement of veterans and mercenaries, and more spontaneous emigration from the densely populated, smaller, southern nomes, begin to fill out the broad floodplain north of Abydos. But even this process was only completed in Coptic times some two millennia later. This illustrates that population gradients need not be population pressures, and that Carneiro's (1972) ideas on the matter represent a far from universal model.

Given the local organization and rudimentary technology of Pharaonic irrigation, it is probable that periodically deficient or excessive floods kept population levels well below carrying capacity, particularly during times of incompetent government. So, for example, the poor flood of A.D. 1877 was only 2 m. below average, but it left as much as 75% of the land of some provinces unirrigated and therefore uncultivable. Similarly, excessively high floods, such as in A.D. 1818-19, breached transverse dikes, razed settlements, destroyed food stores and seed stocks, and decimated livestock. Control over such natural catastrophes was technologically impossible in Pharaonic Egypt. And, at the administrative level there is no evidence for centrally-organized food storage and redistribution until the mid-18th Dynasty (ca. 1450 B.C.), when the local temples assumed redistributory and managerial functions that could potentially serve to alleviate the impact of periodically poor crop yields. Expansion of populations to levels somewhat closer to carrying capacity should therefore have been increasingly possible during times of effective government. Conversely, the negative demographic impacts of recurrent intervals of economic decline would have been accentuated.

The available information on fluctuations of the Nile floods indicates a general downward trend during the third millennium from the 1st Dynasty to the end of the Old Kingdom, with one or more sets of catastrophic Nile failures between perhaps 2250 and 1950 B.C.; flood levels generally improved thereafter, with at least 28 exceptionally high floods of disastrous proportions ca. 1840-1770 B.C. (see Bell, 1970, 1971, 1975). Floods remained generally high until about 1200 B.C., after which they declined rapidly and then remained lower until at least the time of Herodotus. These trends are closely comparable to those documented by radiocarbon-dated lake-level or flood-discharge fluctuations in the central Sudan, in Ethiopia and the Kenya Rift, as well as in the Chad Basin and southern Sahara. When calibrated to calendar years they can be dated more precisely: critical reductions of lake levels and stream discharge began 2700±100 B.C., were reversed in the wake of substantially wetter conditions in subsaharan Africa 1850±50 B.C., with another negative hydrological trend beginning 1200±50 B.C.

In the Nile Valley, there was a 30% decline in discharge during the course of the Old Kingdom, a trend that would have favored greater reliance on artificial irrigation. It is also difficult not to see causal linkages between the disastrous economic recession or the collapse of the political order after the death of Pepi II (ca. 2260 B.C.) and the Egyptian "lamentations" describing Nile failures, desiccation of marshlands, severe famine, general poverty, and mass deaths. During the second half of the Middle Kingdom (2040-1715 B.C.), a new form of stress was created by the Nile: one flood out of three or four equalled or exceeded the highest floods of the 19th century A.D.. It remains to be explored whether the agricultural system was able to withstand such a battering, and whether the collapse of the Middle Kingdom and the successful infiltration of the Asiatic Hyksos were preconditioned by Nile-related economic deterioration. For the late Ramessid period there is significant evidence that food prices–with respect to metals–were rapidly inflated ca. 1170-1100 B.C., most likely in response to inadequate harvests and low Nile floods. The significance of the inferred ecological stress for the abrupt decline of Egypt during the 12th century B.C. may have been considerable.

These examples have not yet been proven beyond reasonable doubt, but they serve to suggest that major segments of ancient Egyptian history may be unintelligible without recourse to an ecological perspective. They further suggest that the cyclic crises in hydraulic civilizations that Wittfogel (1938) attributed to social disequilibrium, in response to overexploitation of the masses by an unproductive ruling bureaucracy, may in fact have rather different explanations, such as the recurrence interval and magnitude of natural catastrophes.

A multi-tiered economy was already established in Egypt by 3000 B.C., judging by the monumental architecture of the 1st Dynasty, while complex social stratification in the urban sector is abundantly evident from the written records of the Old Kingdom. Yet the Mesopotamian model of rapid population growth leading to greater competition for water, increased labor efficiency, intensified irrigation, a more intricate division of labor, social stratification and, ultimately, state superstructures (Adams 1972), cannot be documented for Egypt. Competition for water was never an issue, except locally. At the social and administrative level, flood control and irrigation were also managed locally, and well into the 19th century A.D. most Egyptians continued to live the traditional way of life in villages and small centers where division of labor and class distinctions remained minimal, in a subsistence enomomy based on irrigation. Although Old Kingdom Egypt (ca. 2850-2250 B.C.) was strongly centralized in terms of its political superstructure, there is reason to assume that the infrastructure, at least in Upper Egypt, continued to function on more traditional lines via a number of indirect agents and agencies that mediated between the capital and the local communities. Ecological problems appear to have been preeminently handled at the local level, so that the development of a professional, full-time bureaucracy must be related to a different social impetus. There is, then, no direct causal relationship between hydraulic agriculture and the development of Pharaonic political structure and society.

Hydraulic agriculture did indeed provide the indispensable economic resource base for the complex, state-centered society that emerged in the form of the Old Kingdom, but high economic productivity is essential to any complex society. More relevant to the socio-political system of Pharaonic Egypt is the socio-economic anchoring of the nomes into the explicit ecological framework of a riverine oasis. These primeval nomes appear to have provided the necessary political infrastructure that allowed the military unification of Egypt. Similarly, there is growing evidence that the economic history of ancient Egypt was primarily one of continuous ecological readjustment to a variable water supply, combined with repeated efforts to intensify or expand land use in order to increase productivity. It is in this sense that hydraulic civilization in Egypt remains inconceivable without its ecological determinants, but not by a linear causality model of stress favoring irrigation development, so creating a managerial bureaucracy, and ultimately leading to despotic control.

The Egyptian case study outlined here appears to have implications for other, early hydraulic civilizations. There is good reason to believe that sociological hypotheses are by themselves inadequate to explicate the processes involved in the emergence of floodplain civilizations. Indeed, it would appear that the origins of early irrigation civilizations are far more complex than existing assumptions and paradigms allow. It therefore becomes pertinent to reexamine other critical areas from an ecological perspective.

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