PHYSICAL AND CULTURAL PROPERTIES OF ANCIENT WATER MANAGEMENT

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Contents

Summary

Water is the most precious natural resource that can be manipulated and controlled by humans. It covers two-thirds of the earth's surface and comprises 50% to 75% of the human body. Perhaps the principal determinant shaping the natural topography is the amount and kind of water moving across a landscape. Nevertheless, only 2.5% of all the

earth's water is freshwater and accessible to terrestrial life. For humanity, water access and use is like food, sex, and shelter, a basic need and one always satisfied within culturally proscribed rules and regulations. The elucidation of the origins and maintenance activities associated with the development of complex water systems provides a window into how humans engage fundamental aspects of their economy, political organization, and power relationships. Why is an anthropological approach to water and its use important? It is a timely and pressing concern, one requiring cross-cultural examination as well as chronological depth to understand fully our mistakes and our successes in attempting to manipulate water. It immediately affects everyone, every day. The built environment—that is, the way humans significantly change their landscape—is frequently a direct consequence of water management practices, and the built environs in which we live are always connected fundamentally to water availability. As a contemporary concern, both natural and artificial water resources are increasingly becoming severely stressed. For example, the recent damming of the upstream margins of the ancient Euphrates—within the same fertile crescent as the earliest experiments in canalization were identified—may strengthen an expanding Turkish economy. A downstream water deficit into Syria and Iraq, however, will surely inflame hostility in a region already ravaged by conflict. Oil will not be the only liquid resource that triggers global crises from within a Middle Eastern theater. As early as the second millennium B.C.E., one of history's first treaties was recorded between the city-states of Umma and Lagash and was composed in part to settle water claims along the same Euphrates drainage. A deeply enduring set of factors affect water allocation and use through time and space, factors that warrant revisiting. Because water is essential, controllable, and responsible for shaping much of the natural and built landscape, a complex set of interrelationships between people and their chosen environment evolves. If we can understand better the economic and political variables influencing the earliest and least complex civilizations, we are then in position to more clearly assess the causal stimuli affecting aspects of social change today.

1. Introduction

Water management is the interruption and redirection of the natural movement or collection of water by society. With or without living consultants or extant texts, dams, reservoirs, canals, and wells reveal alterations to a landscape that permit an evaluation of a group's land-use practices. The scale and complexity of these features provide archaeologists, ethnographers, and geographers with a powerful database for examining economic behavior.

For organic matter, the presence of water is life itself. Humans require a minimum of two to three liters of water a day in a settled environment under normal living conditions. Clearly, this amount can vary with levels of work activity, physical differences in body type, and environmental conditions. In the dry sands of the Negev Desert, home of some of the earliest successful adaptations to severe aridity by the settled Nabataeans, present-day nomadic families (six individuals, two camels, one donkey, two dogs, and ten sheep) survive on 18 cubic meters of water a year. This can be juxtaposed with the excessive consumption habits of the average U.S. citizen, who uses more than 225 liters (0.225 cubic meters) of water daily.

Although water has several unusual properties, two of them are particularly important for any discussion of settled community life. Fluidity is that condition of a liquid that permits ease of transport. Water does not usually require beasts of burden or wheeled vehicles for its immediate relocation, and thus its cost to the consumer is intrinsically low. Gravity flow is the characteristic of a fluid to move from higher to lower elevations via a path of least resistance. This is the cardinal principle in the manipulation of water within a canal scheme, but the primary obstacle to water control in rugged areas.

The properties of fluidity and gravity flow are responsible for two additional conditions imposed by human managers. The first involves the many mechanical problems associated with lifting water vertically. Its bulk and unwieldy dimensions require sealed containers for this movement. A second condition imposed by fluidity and gravity flow is the ability to divert or abruptly cut the supply of water to a consumer. Diversion dams and conventional reservoirs with sluice gates permit individuals or a small group of users to treat water as a commodity. Water is frequently a single-source medium, and the initial investment in controlling water, particularly apparent in irrigation schemes, is to localize points of distribution through sluice gates and related features.

2. Climate and Geomorphology

Water use is partially conditioned by the natural environment. Although most environments can be transformed into agricultural settings, given significant technological and labor investments associated with water manipulation, regional differences in climate and geomorphology dictate the amount of work necessary. Tolerable climatic conditions for agriculture are based on precipitation rates and temperature (i.e. evaporation and transpiration rates). By scheduling around seasonal fluctuations in these variables, water can be manipulated to an agricultural end within an otherwise inhospitable natural setting. Geomorphology is more difficult to modify and represents the principal obstacle to water control in a climatically acceptable environment. The primary geomorphological variables conditioning water management are topography and soil permeability (the latter measured by rates of seepage).

2.1. Arid Regions

In the New World, the most celebrated early centers of complicated, region-wide water management appeared in coastal Peru (and later in highland Peru, Ecuador, and northern Bolivia), highland Mexico, and the U.S. southwest. In the first two areas, the topography is precipitous and associated with relatively small, less consequential natural drainages, especially when compared with Old World civilizations. In Peru and to a degree in highland Mexico, water management systems utilized the topography as an advantage in tapping rapidly moving water over steep gradients. Terraces, dams, aqueducts, and canal networks took on a valley-limited drainage focus knit together by empires.

The seats of primary state development in the Old World were Egypt, Iraq, southern Pakistan and western India, and west central China. In each instance, a major river meandered through these arid territories. Although sometimes associated with unanticipated flood levels, these rivers represent not only permanent sources of water

but also abundant stores. The topographic relief associated with them in proximity to the early state is gentle, particularly when compared with New World examples. This condition allowed extensive canalization in most cases, restricted only by the breadth of the floodplains defining these old, slow moving drainages. Although elaborate diversion dams were clearly perfected, conventional dams with reservoirs or sophisticated terracing systems (characteristic of the Peruvians) were little deployed (Tigris–Euphrates notwithstanding; **see *Section 4.2.3 Canals*)**. Civilization was in part defined by the course of these great rivers.

2.2. Humid Regions

The Maya lowlands is the principal humid region in the New World where complex water systems evolved. In a zone of limited relief and abundant though seasonal rainfall, the Maya pioneered intensive swamp agriculture as well as terrace systems. Well-designed dams for the deliberate entrapment of water within naturally low-lying areas permitted the drainage of excess water during the wet season and its judicious distribution during the dry. Other secondary societies adopting potentially similar techniques may have been the Woodland and Mississippian chiefdoms of the southeastern United States as well as the groups associated with the intermediate area of northern South America. These latter societies took advantage of major riverine settings, generally unlike the Maya.

In the Old World, early tropical intensive water systems are poorly reported from Sub-Saharan Africa, though West Africa may be expected to yield some evidence of intensive water manipulation as a later state development locus. The best evidence comes from Southeast Asia, principally from Sri Lanka, Cambodia, and Java. Here, rainfall rates are comparable with those recorded in the Maya lowlands with similar topographic aspects. None of these principal early state centers commanded a major riverine arterial except for perhaps those of Cambodia.

3.Societal Use of Water Resources

In addition to the social and technological water management adaptations made for the immediate production and consumption of food within complex society, other kinds of activities and facilities were promoted through the availability of water. Most of the material remains identifying nonagricultural water features are not clearly divisible from those put to agricultural ends or separable from the mundane access to potable water sources. Frequently, water management systems functioned to accommodate many societal uses.

3.1. Transport Canals

Water is used by complex societies in several obvious ways as well as a few less apparent ones. It has served as a medium of communication and transportation beginning with the first maritime voyage, probably with the colonization of Australia some 40 000 years ago. Riverine navigation is clearly as ancient. Maritime exchange over extensive reaches is chronicled between Harappan cities along the Indus and Persian Gulf states of Sumeria as early as the third millennium B.C.E. Massive amounts of tribute as well as locally marketed goods were transported to the Aztec island capital

of Tenochtitlan within the lake region of the Basin of Mexico. Transportation canals have a celebrated and seemingly early establishment in Italy (Venice) and Flanders (Bruges) by the 1300s. However, the earliest recorded transport canal, constructed by 130 B.C.E. and terminating in the Han capital region of west central China, was approximately 124 km long and designed to facilitate grain shipments—although irrigation was practiced along its length. Clearly, the role of navigation among early states cannot be minimized.

3.2. Moated Defenses

To protect and defend ancient states, water was skillfully manipulated. A moat surrounding a redoubt is perhaps best characterized by the medieval castles of western Europe, but a clay model of the city of Nippur dating to 1800 B.C.E. has a moat outlining its perimeter. The technique also has deep roots further to the East. Spectacular examples dot the Mogul landscape of western India and Pakistan by the thirteenth century C.E. and moats are clearly identified by the eighth up to the twelfth centuries at the Angkor Complex of Cambodia. Perhaps the earliest evidence for a moated community in Southeast Asia comes from the third century B.C.E. site of Co Loa, 15 km northwest of Ha Noi, Vietnam, on the floodplain of the Red River. However, moated towns may have been quite widespread by this time throughout portions of Thailand and Cambodia, though dating concerns linger.

Independent of the Old World, the Maya constructed ditch and rampart systems by the second century C.E. At Becan, Campeche, Mexico, for example, the ditch circumscribing the town apparently did not hold water, in spite of an aguada, or pond, immediately above the feature. It should also be noted that the Aztec island capital of Tenochtitlan positioned within greater Lake Texcoco provided that city with a clear defensive advantage, though the site's geographical location was not initially selected for this advantage.

3.3. Defensive Inundation

Sometimes irrigation systems were deployed as natural deterrents to outside aggression. In the Maghrib, an African lord/chief had the system of diversion weirs—designed to spread water—shut off along a cultivated wadi system to direct floodwaters into a Roman (Byzantine) encampment. Canal systems in medieval Valencia, Spain, were deliberately flooded to severely disrupt invading armies. The Maya of Acalan conducted a similar strategy when the Spanish attempted to subjugate the dispersed populations of the southern Maya lowlands. Although irrigation systems are shown below to stimulate their own sources of unrest, they can provide a means of area-wide protection against outsiders.

3.4. Flood Control

Water is also managed by complex communities for drainage or flood control, but even nomadic or pastoral groups will flood-irrigate wild grasses for edible tubers or inundate meadow pasturage for fodder. Some argue that all water manipulations represent levels of drainage control, even where water is scarce. In the present context, however, drainage control refers to the storage or diversion of damaging excess water. Flooding

excesses may have been the major stimuli for the hydraulic state in China as well as other Old World civilizations occupying the great seasonally inundated rivers of the world. Rice cultivation, especially, is ideally suited to the diversion and management of excess waters where labor is also abundant.

The oldest recorded artificial ditch comes from the Kuk swamp of Highland New Guinea dating to 7000 B.C.E. It consists of a single human-made feature with associated basins, pits and stake hole depressions and complements the origins of agriculture in this portion of the world. The earliest evidence for drainage channels in China is documented from Anyang, dating to 1100 B.C.E., these ditches being unrelated to agricultural pursuits. In the agora of Morgantina, Sicily, the fifth-century B.C.E. Greek occupation established the oldest known covered-drainage system in the West, though earlier conveyance systems are well reported. Storm waters flushed out latrines and sewers, carrying the effluent to irrigated fields, especially tree crops.

In the New World, a possible drainage canal issues from a dam and debouches into a floodplain field of a few hectares at the Olmec site of Teopantecuanitlan (1200 B.C.E.), Guererro, Mexico. Also, drainage canals date as early as 850 B.C.E. at the type site of Chavin de Huantar in Peru.

3.5. Nomadic/Sedentist Symbiosis

The interface water has provided between sedentary villagers and pastoralists warrants greater attention from a non-agricultural perspective. Although these two mobility-opposed adaptations maintain high levels of tension during interaction, their symbiosis has allowed the survival of both organizational systems in many parts of the world. Meat, milk, and wool or hide have been exchanged for domesticated plant resources and town-crafted trade goods for centuries. The neutral ground associated with a permanent water source, as a well or reservoir, within an otherwise arid environment may represent the staging arena for such events. At Jericho, during the Pre-Pottery Neolithic (8000–7200 B.C.E.), a sizable spring was maintained outside the main wall and tower enclosing the town. Although it was within the architectural capabilities of the townspeople to include a portion of the spring behind the wall and thus secure a major source of potable water otherwise unavailable during siege, this was not done. However, such a design may have promoted pastoral exchange at a neutral location away from the threatening enclosure of the town proper, but near enough to ease the fears of a vulnerable urbanite.

3.6. Water Ritual

The role of water in ritual context occupies a place in all societies. Religious appeals to supernatural forces for adequate quantities of water escalate during periods of extended drought. In drought-stricken Medieval Valencia not only did the incidence of interpolity warfare increase but also Catholism received renewed interest. Water is also frequently used as an unction in symbolic healing rites (“holy water”) or as a libationary offering to various deities. Its cleansing properties permit its use as a symbolic medium for bathing the soul. The argument for the ritual appropriation of mundane and everyday activities associated with water’s use by a controlling elite is articulated with

ethnographic and ethnohistoric examples from Bali, highland Chiapas, Mexico, and Madagascar.

4. Water Management Techniques

Water systems operate at several levels of social complexity. The physical systems that manage water are not only functional and immediately economic, they may also have symbolic implications for a society. Symbolic statements are both made and received by groups within a society with grand architectural investments sometimes manipulated by the political economy and its controlling elite. In many ways, symbolic statements reflect the regulatory principles organizing a society; aspects of societal organization that reveal elements of dominance and subordination.

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Biographical Sketch

Vernon L. Scarborough is a professor of anthropology at the University of Cincinnati. He has taught and conducted fieldwork at the University of Texas at El Paso, the University of Khartoum, Sudan, and the University of Peshawar, Pakistan. In addition to ongoing water management studies in Belize and Guatemala, he has worked in the Argolid, Greece, and most recently in Bali, Indonesia. His topical interests remain settlement, land use, and water management in the context of the archaic state.