WATER MANAGEMENT AND EARLY CIVILIZATIONS: FROM COOPERATION TO CONFLICT

Fekri A. Hassan

Institute of Archaeology UCL
The designations employed and the presentation of material throughout this publication do not imply the expression of any opinion whatsoever on the part of UNESCO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

The authors are responsible for the choice and the presentation of the facts contained in this book and for the opinions expressed therein, which are not necessarily those of UNESCO and do not commit the Organization.
ACKNOWLEDGMENT

This article is a contribution from UNESCO’s International Hydrological Programme to the World Water Assessment Programme. It was prepared within the framework of the joint UNESCO–Green Cross International project entitled “From Potential Conflict to Co-operation Potential (PCCP): Water for Peace,” and was made possible by the generous financial assistance of the Japanese government.
CONTENTS

Summary 1
1. Introduction 2
2. Foragers in Nature 3
3. Agriculture: Overcoming Climatic Variability 4
4. Early State Societies: The Benefits of Cooperation 5
5. Kings and Priests: The Idea of Order 6
6. Early States: Managing Inequality 6
7. The Proto-Urban Scene: Water for Cities 8
7.1. Greeks and Romans: Globalizing Water Technology 8
8. The Clash of Empires: The Thirst for Water 9
10. The Moslems: Waterworks and Water Courts 10
11. The Rise of the West: Industry and Water 11
13. Water Wisdom 12
WATER MANAGEMENT AND EARLY CIVILIZATIONS: FROM COOPERATION TO CONFLICT

Water scarcity is a function of cultural activities. Throughout our long journey from the dim past of prehistory to the present our demand for water has spiraled, and on balance our needs have often exceeded water availability in the successive stages of our cultural evolution.

The transition from hunting-gathering to agriculture signaled a major change in our relationship with water as irrigation canals transported water beyond its natural setting. As cities emerged, the need to supply them with water climbed as they grew more crowded and bigger. Industry not only created more demands for water but also began to modify and pollute water resources in an unprecedented way.

The means for dealing with the relative scarcity of water created by increasing demands relative to water available when and where it is needed have included (1) technical innovations, (2) social transformations, and (3) normative and ethical formulations. Our current situation, which involves local scarcities to certain users, cannot be resolved solely by technical fixes or economic measures (e.g., pricing) without implanting social institutional changes and a common vision based on transcultural ethical considerations.
1. INTRODUCTION

Water is the mainspring of civilization. This was recognized at the dawn of civilization in Mesopotamia and Egypt. Water was conceived as the source of all things, eternal and primeval.

In Mesopotamia, Iraq, the god of water, Enki, was entrusted with “me,” the universal law governing all existence. Enki, whose mother Nammu was no less than the goddess of wisdom, poured water to make the earth fruitful, stocked marshes with fish, and erected sheepfolds. Wisely, he also appointed special deities to oversee his works and innovations.

This early recognition of the link between water management and civilization is the subject of this article. My aim is to clarify how the development of early civilizations and water management has evolved together with mutual interactions.

I will argue that water shortages are nothing new, and that throughout the history of our common human civilization various solutions were implemented to overcome water scarcities and enhance water security. However, I will submit that such solutions were always short-lived — a temporary relief — because the social and cultural consequences of each solution led to a gradual, cumulative increase in the demand for water.

Civilizations are constrained directly by the quality and quantity of available safe drinking and subsistence water. They are also constrained indirectly by the influence of water on food, energy, transportation, and industry.

Human societies have throughout history found new means to secure availability of water where they settled. They have devised ingenious methods to harvest, transport, and store rainwater, spring water, groundwater, and even air moisture. Human societies will thus continue to search for new sources of water, but the cost of procuring water is a function of the combined cost of extraction/harvesting, transportation, treatment, storage, and delivery. There is thus inevitably an economic aspect of water availability. As water scarcity increases, the cost of water also increases. Accordingly, the fundamental issues throughout history have been: can we afford to meet the increasing cost of waterworks? who pays?, and who benefits? These questions imply that there are various social and political aspects to water economics. In turn, social issues are never divorced from beliefs concerning the world, the social order, and ethics.

This leads to the further conclusion that current water scarcities cannot be overcome simply by new technologies. All technological innovations aimed to relieve water scarcity are embedded in a social and an ideological matrix. All such innovations also have an impact on society and its ideology.

My main thesis is that water shortages have been an engine of human innovations; propelling, motivating, and prodding societies to devise, accept, and perpetuate solutions to water scarcity. Water is thus the mainspring of civilization and its entire works. However, the key element in my thesis is that relief mechanisms have so far always entailed, in the long run, greater demands for water than what is available at prevailing withdrawal, transport, and treatment cost. The reasons for this paradox lie in the fact that the historical solutions to water scarcity involved:

- increasing population size
- greater water consumption per person
- progressive depletion of utilized water resources
- progressive deterioration in the quality of water.

Water as an essential ingredient to life is one of the fundamental resources utilized by human societies. Individuals in any society operate in groups to perform certain tasks that enhance their chances of survival and well-being. Among such tasks is food
gathering and procuring water for domestic use. Beyond this fundamental level, societies have developed means by which they can overcome occasional food shortages, ensure sufficient water supply, protect themselves against external dangers, manage intra-societal conflicts, and maintain a viable mating network. It is too simplistic to think of how societies work only in terms of “adaptation” to an external environment, since the internal dynamics in any society as its members seek to meet multiple objectives lead to social and cultural innovations. As society as a whole copes with such innovations, its pre-existing relationships with resources change. In general, human societies have evolved from small, mobile bands of subsistence foragers to huge conglomerates of sedentary communities as complex nation-states. This evolutionary development, which was not unilinear, gradual, or universal, was marked by a major transformation in the way societies managed their water resources. In this brief overview, I have attempted to highlight the sequence of key benchmarks, the thresholds in water history that signaled dramatic changes in water management issues and were, in turn, of significant historical consequence over the last 25,000 years.

2. FORAGERS IN NATURE

We begin at first with hunter-gatherers, situated in sub-arid drylands during the coldest maximum of the last Ice Age, between 25,000 and 16,000 years ago. These foraging ancestors were faced with extremely dry, arid conditions. Wild game diminished and vegetation was thinned. They survived by developing traps and the bow and arrow to capture small animal game, and by devising grinding and pounding equipment to retrieve food from nuts, rhizomes, and cereal grains. Geographic and climatic conditions played a key role here governing the distribution of surface (rivers, lakes, ponds) and groundwater accessible at the surface (springs). Throughout human history until that time gathering plant foods, hunting wild animals, fishing, and fowling were the main source of subsistence. Rainfall and temperature played the key role in the distribution of wild plants and animals. As foragers and hunters, people were tuned to seasonal variations in edible resources. In general, the available yield from wild resources for human consumption was only sufficient to sustain a small number of people within the perimeter of a territory determined by a day return journey to home base. The size of a local group at any one time of the year thus rarely exceeded fifty persons, and was often between fifteen and twenty-five people. Even such small groups could not survive in the same locality all year round because of seasonal variations in food availability. As such, seasonal scarcities or abundance in certain desirable resources prompted people to relocate frequently in tune with the seasonality of rainfall and temperature variations which were critical for the growth and maturation of plants and the movements of animals. In certain areas, particularly deserts, the low density and patchiness of resources necessitated frequent movements regardless of the season. Before the invention of pottery to store water, hunters and gatherers did not live far away from drinking water resources. They chose locations neither too distant from water nor very close to it, in order not to scare wild game or suffer from insects drawn to humidity. Containers from wood or bamboo were probably used, but in areas where ostriches were abundant, ostrich eggshells were used as water containers to be used on hunting trips.

Water was clearly a limiting factor during prehistoric times. Average annual rainfall and seasonal variability limited biomass and the critical portion of that biomass containing high quality protein necessary for healthy human growth. The evolution of food extraction and processing tools was markedly slow. Implements (tools) fashioned from stone (and therefore more likely to survive than other tools) reveal that it was not until approximately 25,000 years ago that the tempo of technological change was
accelerated. Although modern humans (*Homo sapiens sapiens*) appeared and spread in a period from approximately 200,000 to 60,000 years ago, the technological take-off manifest in the manufacture of composite tools and the widespread use and sophisticated manipulation of very small stone tools (microliths) happened many millennia after our own ancestors inherited the earth.

In tracing back our relationship with water, it is important to keep in mind the overall size of the world human population and the size and density of local populations. Certainly, one of the causes of the current local scarcities of clean water is a result of a very large world population and huge concentrations of people in urban centers. By contrast, our primeval conditions were characterized as mentioned above by roving small bands that interacted in regional kin-groups of 500 to 1,000 people. The world population could have rarely exceeded 10 million people, and their impact on natural resources was accordingly far less than that characteristic of later periods.

### 3. AGRICULTURE: OVERCOMING CLIMATIC VARIABILITY

By 16,000 years ago, and especially after the global warming and until approximately 10,000 years ago, the world experienced frequent climatic oscillations as global climatic conditions were undergoing major changes in the heat budget and the differences between ocean and earth temperature. In certain localities wild cereal grains proved to be a viable staple food, allowing communities to settle near fields to harvest and process foods, utilizing a new technology based on sickle stone tools. The use of grinding stones to process cereals also became widespread. The wild cereals proved to be an alluring resource. Although it required a relatively higher amount of work per unit of yield to extract tiny seeds from small weedy grasses, and at that time the cereal plants were scrappy grasses, the amount that can be harvested from extensive grass fields was sizeable. Moreover, in arid conditions, it was possible to store cereal grains to be consumed when food was scarce. A diet of cereals with small supplementary amounts of legumes and pulses is also fairly nutritious.

In Southwest Asia, a return to ice age conditions from 13,000 to 11,500 years ago transformed the landscape and influenced the distribution of wild cereal stands and animal game. These changing climatic conditions encouraged some groups to become fully committed to growing wheat and barley as a staple food in Southwest Asia. In China, some communities began to depend on rice as a significant source of food. In Southwest Asia, goats and sheep were added to the subsistence base 10,000 years ago. In the Egyptian Sahara, where foragers were taking advantage of the greening of the desert due to an increase in rainfall associated with post-glacial warming, episodes of reduced rainfall forced communities to depend on seasonal ponds or springwater. One of the remarkable recent discoveries is the growing evidence for cattle keeping in Africa almost at the same time as sheep and goats were domesticated in Southwest Asia.

The beginning of a strategy focusing on keeping goats, sheep, or cattle with or without horticulture appear to have been initiated in the natural habitats of these crops and animals. In the long run, large aggregation of people close to the stands of cereals and legumes was associated with a trend toward year-round settlements. One of the reasons for this was to guard stored food resources. Another was the nuisance of having to carry the heavy food processing stones now needed in large numbers to cope with the large volume of food to be processed. Although initially the co-residential communities were still only slightly larger on average than the size of bands, it was advantageous to have a large number of women, men, and children to harvest wild grain when it matured. In its wild state, the grains were easily detached from the stem and thus if not harvested within weeks of maturation it was practically lost. The beginnings of a trend to increase, even slightly, the number of inhabitants,
and to remain for most if not the whole year in a settlement significantly altered the relationship between people and their resources, including water.

One of the most important changes was the impact on local wild animal populations. Over-hunted or alarmed by intensive human predatory activities, wild animals either retreated to safe areas or began to dwindle in numbers. This encouraged people to either keep animals in the settlements, exchange grain for game captured by specialized hunters, or grain for meat or milk from herders. A commitment to keep animals entailed providing them with water or taking the herd to a waterhole or a stream. Vessels made of baked mud (pottery), for which there is now evidence in China and North Africa predating 9,000 years ago, proved to be advantageous for keeping water in houses and in transporting water from lakes, streams, or springs distant from the settlement. The use of goatskins to carry water was an added value to having goats for milk and meat.

For some groups, the idea of relocating settlements close to permanent springs and streams was another solution to the problem. This idea had other merits because of the availability of cultivable land close to streams. Natural irrigation provided water needed for growing crops. Dependency on water from streams also mitigated against the capricious pattern of rainfall in arid and semi-arid lands. Not only is rain seasonal with marked variability from one year to the next, but also it is also not certain that rain will always fall in the same area.

4. EARLY STATE SOCIETIES: THE BENEFITS OF COOPERATION

Having overcome the major problems associated with dry farming, the earliest generations of farmers in river valleys found themselves after a few generations eventually faced with periodic water shortages when the rivers dried up, silted, or changed their course. In response, they dug canals and drains, and constructed dikes and earthen dams in order to either get rid of excess water or bring water to parched fields. In a sense, the first attempts to manage drainage and irrigation water, no matter how feeble or elementary, marked a revolutionary shift in the way people interacted with water.

There were also other changes that proved in the long run to have been equally revolutionary. People from neighboring villages made deals and mutual support pacts with their neighbors. This included cooperating to repair a breached embankment or dig a canal. They suffered equally from flood disasters, and went hungry when droughts ruined their crops. Sharing grain and other foodstuffs in regional networks, using boats or donkeys whenever available, was a successful mechanism to buffer local communities against food shortages.

Goat and sheep or cattle herders still faced the capricious variations in rainfall. They too needed to trade with farmers. Droughts coupled with the high cost of animals relative to grain also encouraged food exchanges between farmers and pastoralists. The nomads eventually became a major force in history because their lifestyle lent itself to raiding and militancy. In good years, herds are plentiful and herders prosper and become numerous. However, when pastures wither and waterholes dry up, especially when farmers are better off, the peaceable pact between pastoralists and farmers may break down.

During the riverine phase of farming, aggregation of settlements near favorable flood basins constrained the options for population movement and encouraged local groups to remain together. This seed of enhanced group cohesion was in sharp contrast with the ethos of fission, roving, and roaming that once characterized hunters and gatherers. Even the pastoral nomads were no longer weakly organized like the regional agglomerates of foraging bands. The importance of waterholes and pastures
led to a sense of territoriality and organization (coordination) within and between groups of movements over long and short distances. This encouraged the emergence of a managerial strategy based on tribal affiliations and political organization.

In rural settlements emergent problems were sanitation, occasional food shortages, and relative scarcity of animal protein, which added a heavy disease load to children and adults. This heavy disease load was compounded by malaria and infectious diseases promoted by frequent exposure to others from one’s family and community, as well as close contact with animals.

The initial riverine/pastoral phase was thus an eventful period heralding changes in the way people interacted with water resources but, perhaps more importantly, it also created the conditions for some of the fundamental changes in the organization of human societies and how they interacted with other societies.

5. KINGS AND PRIESTS: THE IDEA OF ORDER

By 5,200 years ago, complex state societies made up of coalitions of regional groups united by a king, emerged in the context of riverine societies to coordinate the social affairs of neighboring villages, defend them from marauders, and manage interregional economic exchanges. In Mesopotamia, the royal institution was linked to the increasing role of temples and priests in social affairs. Kings referred to themselves as Ensi (stewards) of the God, Lugal. Temples became economic foundations with their own estates. The Mesopotamian state was in essence a city-state, with the temple as a central focus of social power. In the Nile Valley, the statelets that existed as regional polities strung along the banks of the Nile were unified in a country-state ruled by a king under the umbrella of a religious ideology from a capital city. The emphasis in Egyptian religion was on funerary rituals that linked the ruling king to departed ancestors who descended from a family of gods. In India, a loose federation of towns emerged over a vast area (65,000 square kilometers enlarged later to 544,000 sq. km). In China, the Shang state dates to 1766 B.C. It was based on a system of lineages (shi) and clans (xing). The shi were corporate units whose members were loyal to their heads. The king (wang) assigned particular lineages to serve as royal personages or high aristocrats. Clans were assigned territories in order to extend the geographic power of the state. The state consisted of a network of walled towns dominated by a royal capital.

The rise of state societies implied greater managerial capabilities for waterworks, resolving disputes within and between regional groups, and facilitating the transfer of famine relief food when needed. The state also entailed a dramatic shift in worldview, social organization, and relationships between societies. The state was in essence linked with the rise of a power elite and state functionaries and with the potential for coercion and persuasion using an extra-local apparatus. The initial phases of the state were dominated by lineages and coalitions of territorially based, kin-related political organizations. Eventually, the role of kinship as a basis for social organization was marginalized and confined to a provincial level as elements of a bureaucratic, extra-local managerial center of power were nudging the political system toward an ideology focused on the person of the king as a steward of God or even the son of God.

6. EARLY STATES: MANAGING INEQUALITY

The early states were a curious mix of centralized authority and semi-autonomous provincial polities with a spectrum from non-kinship to lineage-based organizations. The state was not responsible for or involved in massive irrigation programs, and nowhere is there any evidence in early civilizations for a centralized despotic organization based on elaborate waterworks. In addition, although there are indicators
of feuds and skirmishes, systematic warfare with standing armies was to emerge much later. The state appears to have gained its legitimacy initially from acting as an arm of the God(s) to settle disputes and instill a sense of order in a changing world of chaotic events that ranged from disastrous floods and pest infestations destroying crops to attacks by marauders. The king embodied or mediated the forces of nature by his cosmic connections and ensured prosperity (naturally the people were blamed for any catastrophes because they either did not appease the gods or acted in a way that angered them). Nevertheless, the kings were able to mobilize human labor at a scale much greater than that at a village or regional levels.

A reasonable estimate for the population of the early Egyptian country-state is approximately 400,000 climbing later to about 2 million, with regional units consisting of 10,000 to 20,000 persons at the start. Although the percentage of the adult male population that could be mobilized for hard labor or military operations was smaller than that available at a local level, in absolute numbers, the state could command a much higher number. Marshalling 10 percent of adult males from ten provinces, for example, provided no less than 2,000 men. With 5 percent of all adults from a population of 2 million, the king could mobilize 20,000 men. The king also received revenues from the various districts of the kingdom and it was thus possible to accumulate capital that could be used to undertake emergency relief actions. The success of this strategic move buffered local rural societies against periodic agrarian failures. However, the rise of the state created a destabilizing force. This force consisted of a greater demand for food to meet the progressive increase in the number of non-food-producers, from the king and his court to the scribes and the carpenters. This force gained more intensity as the demand of each of the non-food-producers soared to fit their elevated social status. With an increasing demand for food, the farmers were forced to work harder, to work longer hours, and to beget more children to increase the size of the labor force. Social and ideological mechanisms were put in place to ensure that farmers remained in the fields, living in misery and destitution in hovels and huts.

At the same time, the state elite, the supporting cast of priests, scribes, soldiers, and artisans, retreated to palaces and town houses on royal estates in capital cities and provincial towns. This was the beginning of one of the major forces in world history: social inequality and poverty.

Greater productivity, to feed the peasants and the rising number of non-food-producers, could only mean that more water was needed, especially when the stretched system of production suffered from lack of rain or poor floods. The answer was for the kings to dig longer canals, construct bigger dikes, and, on occasions, to reform the organizational bureaucracy. The earliest major waterwork is the Sadd el-Kafara dam in Egypt. It stands 14 meters high and consists of two rockfill sections with an inner fill of rockwate and rubble. The surface was covered with limestone ashlers arranged in the form of stairs. It dates back to 2690 B.C. to 2950 B.C., at the time when the Egyptians were perfecting pyramid-building technology. The dam was apparently built not to store water but to protect installations in the valley from torrential rain coming down the wadis (ephemeral streams). However, it was in 2100 B.C. that Egyptian kings of the Middle Kingdom embarked on one of the most ambitious waterworks ever attempted hitherto. Responding to a calamitous drop in Nile floods over a period of forty years that plunged the country in an age of terror and political disorder, the kings:

1. Dredged and re-activated an old Nile arm which connected the Faiyum depression to the main Nile River.
2. Cleared and drained potentially arable land in the depression.
3. Constructed a permanent irrigation and drainage system.
7. THE PROTO-URBAN SCENE: WATER FOR CITIES

In some state societies, urban centers for the state elite, craft specialists, priests, and scribes led to the emergence of the earliest large cities with populations of as many as 20,000 to 40,000 persons. The permanent locations of these cities required protection from floods, transport of water, supply of goods through water canals, storage of water in tanks or ponds, and water distribution and sewage systems.

7.1. Greeks and Romans: Globalizing Water Technology

The pace of technological advancement was slow as a result of a closed system of absolute monarchy and monopoly, a religious ideology structured around the glorification of the king, as well as a low rate of economic agrarian growth. The numbers of literate scholars was small. They were not organized in national or international organizations, and their learning devices were not geared for practical knowledge.

The basket remained the only water-lifting device in Egypt until the New Kingdom (c. 3,500 years ago) when the shaduf was introduced, 3,500 years after the beginning of agriculture in Egypt and 1,500 years after the rise of the nation-state. It was not until 1,000 years later that the water wheel and the Archimedean water screw were developed in Alexandria. Archimedes (287 to 212 B.C.) worked with scholars from all over the world in the largest think tank ever developed until that time – the Mouseion associated with the Library of Alexandria. Founded by the Ptolemies (kings of Greek origin who ruled Egypt from 323 B.C. to A.D. 30), the Mouseion hosted scholars such as Euclid and Archimedes who made significant advances in mathematics of cones and cylinders as well as differential equations leading to major advances in hydraulic engineering. The achievements of the Alexandria scholars definitely represent a breakthrough in water history, because they laid the foundations of theoretical hydrology in connection with practical applications.

The Ptolemies who inherited the Macedonian empire from Alexander the Great benefited not only from the knowledge of Egyptians priests and savants, but also from the scholars of Persia. Persia came under the fold of Greek rulers following the defeat of the Persians in 333 to 331 B.C.

The Persians had already made an ingenious contribution to hydraulic engineering by developing a water delivery system known as “qanats” – a subterranean system of tunnels connecting wells and dug using vertical shifts designed to collect and transport water, sometimes over distances more than 50 kilometers long, to extend farming to marginal desert areas by utilizing underground, long-distance transport of groundwater from mountain springs to low-lying farming land. The system was definitely developed by the middle of the third millennium B.C. since there are remains of qanats introduced by the Persians to Egypt at that time.

This method for utilizing groundwater spread from Persia to dry lands in Iraq, Syria, Jordan, Palestine, Egypt, Algeria, and Cyprus. Qanats also diffused to Arabia, the Gulf states and Oman, as well as to Pakistan, Afghanistan, and China. Qanats, in addition, were introduced by the Muslims to Spain, to be exported subsequently to Mexico (Tehuacan), Peru (Nazca), and Chile (Pica and Matilla). This is one of the major early historical examples of the diffusion of water technology from one civilization to another. Although the mechanisms of diffusion have not been fully worked out, they are were in general linked with movements of people, but more importantly linked with ideas in a world that already was becoming a global village with effective networks of communication and transport, both maritime and overland. The Romans, who in essence capitalized on the knowledge accumulated and generated by the Ptolemies and the Persians, were instrumental in the spread of hydraulic engineering to various parts of their empire. The Nabateans who occupied
the desert region in Jordan and Palestine and inherited desert hydraulic techniques dating back to the fourth millennium B.C. came under Roman rule in A.D. 62. The Nabateans had by then constructed more than 1,000 small reservoirs using small gravity dams. The Romans transported the idea to Italy in the reign of Emperor Nero (A.D. 54–68) on the River Arniene, about 50 km east of Rome. Gravity dams were also introduced by the Romans to Turkey, Syria, North Africa, and Spain.

In A.D. 270, the Romans combined their knowledge of arched bridge construction with that of gravity dams to build two large weirs near Shushtar in Iran. This ushered a phase of building weir bridges in Persia that lasted until the tenth century, well into the Islamic period. It was during that century that Muslims in Spain began to develop and improve Roman hydraulics. In Spain dam-building boomed and the country reached its zenith as a world power in the sixteenth century.

Greece and Rome thus left a lasting legacy – that of a cosmopolitan world that permitted the flow of information, ideas, and gadgets on a global scale. This was in a sense the first global information age.

8. THE CLASH OF EMPIRES: THE THIRST FOR WATER

The Persian-Greek wars and the subsequent clashes between the Romans and the Ptolemies and the Persians were the culmination of a phase of clashing empires. The age of ancient empires culminated in the third century B.C. with the emergence of the Roman Empire (272 B.C. to A.D. 410) – an empire that extended over the whole Mediterranean littoral.

This stage in world history began with the rise of the first empires in the Near East, with Egypt joining c. 1500 B.C. The cradle of civilization from the Euphrates to the Nile was the theatre of warfare as Sargon of Akkad annexed Sumer c. 2300 B.C in a first step to establish an empire that extended to include northern Syria, most of northern Mesopotamia, and parts of western Iran. Sargon maintained a standing army of 5,400 soldiers. The clash of empires in the region entered a new phase when the army of Alexander conquered Egypt and Persia and pushed farther east to India.

This phase in the history of civilization marks the emergence of military officers and mercenaries as a major force within and between societies – a force of heavy economic demands and a powerful set of ideologies and practices. The age of empires from 2300 B.C., culminating c. 1500 B.C., until the founding of the Roman Empire, followed in the wake of the establishment of city-states in Mesopotamia and the nation-state in Egypt beginning c. 3200 B.C. This was mainly a result of the voracious appetite for revenues and trade goods by the state elite.

In addition, a thousand years of agrarian developments under state rule pushed the early agrarian societies to their uppermost level of production, and large-scale military operations by armed forces dedicated to warfare was a novel strategy to secure more land and more laborers, and to guarantee the flow of coveted exotic goods for the consumption of the elite. It may be said that conflict over water rarely leads to war. But we fool ourselves if we do not consider that water is an indirect cause for many conflicts. Wars for agricultural products, for example, are wars for the water resources essential for farming. Wars for cotton, sugar, or rubber are wars for water. The spread and expansion of waterworks under the Romans and the world preoccupation ever since with hydraulic engineering and water technology is an excellent indicator for a thirst for water as the indispensable ingredient for economic activities from agriculture to mining. Water scarcity under the Romans was a result of greed for water – a greed precipitated by the desire for greater production to meet the demands of the imperial elite.

It may also be stated that war and conquest only mean that resources are re-allocated from one region to another, increasing the misery of many regions for the
benefit of one country. Grain shipped from Egypt to Rome only meant that the suffering Egyptian peasant had to work even harder and had to sire more children. The oppressive conditions under the Romans led to many peasant revolts. When the revolts were crushed, peasants fled to the hills abandoning the fields. Sadly, this situation continued from that time on to an extent that alarmed the Ottomans when they took possession of Egypt about 1,500 years later. In a rare historical document, an Ottoman decree obligated the peasants on pain of heavy penalties to their families and their villages to remain tied to their fields.

The concentration of resources by an imperial power also meant that ambitious reclamation projects could be undertaken, as the Ptolemies did in Egypt, reclaiming the Faiyum province and desert oases. It is remarkable that the Roman period, which entailed an unprecedented phase of economic boom, land reclamation, intensification of agrarian production, and trade on a global scale, was also a period of worsening conditions for peasants and for those who had the misfortune to become slaves.

9. THE METROPOLIS: WATER ARTERIES FOR URBAN LIFE

The Roman Empire left another glorious or inglorious legacy, depending on how you look at the metropolis. Greater Rome had a population of as many as 500,000, more than ten times that of earlier cities. Ptolemaic Alexandria in its heyday also approached 400,000 people.

The water demands of both Alexandria and Rome were met by ingenious solutions. In Alexandria, the city more or less floated on top of hundreds of cisterns fed from a canal connected to a branch of the Nile. In Rome, aqueducts and tunnels were constructed to deliver water to a city that not only needed water for drinking and domestic use, but also for public baths.

A subterranean water tunnel, the Aqua Appia, ten miles (sixteen kilometers) long, was dug, providing 16 million gallons of water per day. By 140 B.C., at great expense, a new aqueduct, Aqua Mercia, supplied Rome with water over a distance of fifty-six miles from the water springs of Subiaco. The aqueduct was elevated over arches and water was diverted into several branches. Every day, over 100 million gallons of water passed through the city, compared with 1 million gallons today in the River Tiber!

10. THE MOSLEMS: WATERWORKS AND WATER COURTS

With the collapse of Rome, the world entered the second phase of global information as Moslems, effectively from the eighth to the twelfth century, integrated sources of knowledge from China to Spain, paving the way for a wealth of world information that was passed on to the Europeans in the late Middle Ages.

Rome had also brought the fold of civilization to the people around the northern Mediterranean littoral, setting in motion forces of change that have since re-shaped the world. The Byzantine Empire also had an impact on the people of the Middle East and Arabia, where Islam emerged in the seventh century A.D.

Under the Moslems (a people who were originally from a barren desert) irrigation waterworks, aqueducts, subterranean qanats, watermills, baths, and fountains spread to many parts of the world.

Moslems also introduced a system of water management and water courts. Attention to hydraulics by the Arabs was one of the main sources both of modern mechanics and industry – the forces that were to shape the world to come.
11. THE RISE OF THE WEST: INDUSTRY AND WATER

Following the defeat of the Arabs in Spain and the weakening of the Ottoman Empire, Western Europe (later to become "The West" as a means to differentiate it from the "Orient", the reference point by which Europe defined its global position), as the beneficiary of world knowledge, began a phase of economic and cultural development based on trade, banking, and maritime exploration. The Ottomans, who ruled and bankrupted a huge tract of the world, and clashed with and subjugated Christian and Moslem countries alike in their quest for imperial power and its economic bonanzas, set the precedent for disguising the clash of empires for water resources and economic goods as a clash of religions and civilizations.

By 1650, the advent of mechanized industry and the introduction of food crops from the New World were associated with a phase of urbanization based on manufacture or commerce – both were under the patronage of the king or the temple. Manufactured goods were exclusively for state functionaries and to be awarded by the head of the state. The expansion of manufacture and trade in later times were not only related to advances in technology, but also to the breakdown in the monopoly of manufacture and trade by divine kings, allowing many individuals to engage in such activities and raising the number of consumers by allowing commoners to have access to luxury goods.

In Europe, the development of medieval towns linked to trade and crafts in a climate of competition and warfare not only made it necessary to secure water for city dwellers, but also made use of water for defense, mills, tanners, and paper makers. Sewage, sanitation, and water pollution became issues of concern, and had a major role in transforming water management methods.

The prevalence of a scientific outlook, however, was instrumental in alerting communities to the danger of deforestation and the drying of wetlands. Science also provided other means for manufacture that eliminated putrefaction and reduced the ravages of epidemics. With increasing affluence, the cities enjoyed the benefits of parks, tree-lined boulevards, and fountains – the Renaissance legacy of a landscape of meadows, fountains, and nymphs.

Fountains became the symbols of the triumph of the city over its water problems and of its prosperity and affluence. Fountains were, in fact, the new temples to water gods.

Canals and water mills in the late eighteenth century paved the way to a world where water is controlled and manipulated. Canals also paved the way for the rise of nation-states by strengthening inter-regional links within water basins.

Egypt, we must recall, became one of the first world nation-states because it was connected by the Nile as a water highway.

The rise of the modern nation-state was closely connected with the management of water on an inter-regional scale for transport, commerce, and industry. Water was now not only needed for agriculture and domestic uses, but also as a raw material for industry and as a source of energy.

Industrialization, over the last 200 years, often in association with urbanization, has thus created great demands for water, competing with the growing demands for water to produce food for the ever-increasing masses of humanity. Industrial water pollution from suspended solids, organic materials, heavy metals, synthetic chemicals, and acidic waste is now compounded with that of pollution by modern farming, such as contamination by nutrients, pesticides, and animal waste.

Industrial farming, involving use of farm machinery, fossil fuels, fertilizers, and waterworks on an industrial scale, as well as scientific methods of breeding and management, provided the possibility of supporting very large populations who in turn became the source of a huge labor force. They became also the consumers of agrarian and industrial goods, with great profits to landowners, bankers, and industrialists. A
part of the profit was re-invested in science and technology to increase the margin of profit.

The share of profit was greater for the industrialized West, at the expense of colonial possessions and less developed nations. The frightful result of this disparity was that poverty was worsened by a population explosion, as large family size for the poor became both beneficial and feasible. More food and modern medicine reduced mortality. Unlike in the West, where industrialization, education, and pensions made small families desirable, leading to a reduction in births as health conditions improved, families in poor countries wanted more children to provide more income and security in old age.

The rise in population since 1650 was also associated with an increase in urbanization. Urbanization was faster in European countries, but it is now accelerating in non-western nations. Urbanization creates severe demands on water and involves serious pollution of water resources, especially in poor countries where urban planning is absent or too costly. Today, more than 1 billion persons have no access to clean water.

12. PRESENT PAST: THE MAKING OF A WATER CRISIS

Poor countries are now facing the dilemma of having to undergo rapid industrialization to face growing population numbers, migration to the cities, and greater demands for the amenities of urban living and a middle class lifestyle. In the process they are stressing existing water resources, hastily and rather inefficiently developing new water resources, overlooking degradation and breakdown of urban water and sewage infrastructure, and failing to minimize or prevent water pollution from modern farming and industrial installations.

Dams and still more dams are developed at the expense of local ecosystems and indigenous populations as demands for both water and energy soar.

Industrial nations face the increasing demand for energy, industry, services, and urban growth. They are inter-linked with non-western countries through a web of economic transactions, and have, accordingly, to cope (for the sake of economic sustainability and world peace) with the relative scarcity of water, water pollution from unclean modern farming, dirty industry, ecologically damaging dams, irresponsible withdrawal of groundwater, and unsanitary water management in urban slums in their own countries and elsewhere in the world.

13. WATER WISDOM

The fates of nations until 300 B.C. were independent. Rome, with a population of 54 million persons (about one fourth of the total world population) in Europe, Asia, and Africa, was the culmination of the growing interdependency of the world nations of early civilizations, the closest to a global civilization in antiquity. The fall of Rome, in my opinion, was not only a result of a threat from its northern neighbors, but also from the heavy cost of a military establishment and an unprecedented stress on water resources, even in the desolate Egyptian oases, with diminishing returns.

Investments in waterworks and water technology were too costly to sustain. In Rome, graft, corruption, ostentatious consumption, and greed prepared the way for the demise of the first global society.

Today, we suffer from the same ills: urbanization, technological advances at great cost that offer diminishing returns, the threat of global climatic change, and a precarious global economy. However, as in ancient Rome, we also suffer from vast, unjust disparity in wealth, development potential, and education.
Did the Roman Empire collapse because it had failed to produce a philosophy of equality and social justice to match its advanced water engineering feats and military prowess? Did Rome, with its great democratic institutions, conquer the world, but fail to conquer its vanity, greed, and blinding, misguided notion of who is Roman and what is truly the national interest of Rome?

Marcus Aurelius was an exceptional emperor. We should not forget these words from his *Meditations*:

To expect that bad men will not sin is madness;  
it is demanding impossibility.  
To allow them to injure others, and demand that they should not injure you,  
is foolish and tyrannical.

I have surveyed the past with a broad brush, overlooking many details and specific cases, in order to place our present predicament in a long-term perspective. My conclusions are that human societies must always cope with unforeseen natural forces. They are most vulnerable when they are stretched to a meta-stable condition – a point of living dangerously when minor perturbations can plunge society into a state of chaos.

Today, climatic change, mostly as an external force, now destabilized by anthropogenic (human-induced) variables, could suddenly and significantly influence the hydrological cycle, air-mass movements, and regional distribution of water resources with serious socio-economic effects.

History also reveals that our problems are not without precedent, except that:

1. Our water demands are rising sharply.
2. Our ability to pollute is global.
3. Our pollutants are more deadly.
4. Our interference with ecosystems is both far-reaching and nefarious.
5. All societies are closely inter-linked so that any regional catastrophe can have global repercussions.

With the change in the scale of our relationship with nature and other societies, we are still constrained by the sentiments, ideologies, and world views shaped in our remote and recent past by nation-states, religious divides, racial discrimination, elitism, consumerism, so-called “rational” economic thinking, faith in technological fixes, and anthropocentrism (the view that we are the masters of nature and that the world was created for our pleasure).

Although I firmly believe that we are at a stage where we cannot forgo advanced technology – indeed we must have recourse to new technological measures to alleviate our current water shortage situation – I am equally convinced from historical hindsight that what we need first is a new vision and a new heart. The current scarcity is a function of uneven distribution of financial and technical resources, as well as an explosive demand for worldly goods.

In my opinion, there is no long-term solution without a change of heart to re-allocate resources to wherever they are needed, regardless of national boundaries, religious barriers, and racial differences, for a better management of our global water resources. Water could, in fact, serve as the midwife for a new just, and hence peaceful, global society. In our dim past, villagers came to each other’s aid to dig a canal to bring water to a parched field or to build a dyke to save a town from catastrophic flood.

Let us also consider the collapse of the Egyptian Old Kingdom, 4,200 years ago, when a series of severe, unforeseen low Nile floods led to a devastating famine. The starved peasants were reduced to eating filth and then their children. Communications
were disrupted; the peasants rioted and began to plunder places and tombs. The government collapsed and the social order was overturned.

The country, shattered and dying of hunger, was put back together by rulers who realized that a civilization could not be sustained without two things: (1) attention to water management; and (2) an ethical code of justice and compassion. The kings who succeeded in putting the country back together undertook major hydrological projects. In addition, they were no longer rulers by divine right. They proclaimed instead that they were sent by the Gods to protect the poor, feed the hungry, and help their neighbors. For the first time, the names of the kings were conjoined with the name of Ma’at, the Goddess of justice.

Allow me to finish with a reference to Antoine de Saint Exupéry, writing at a time when Europe was threatened by destructive forces of its own making. In his *Flight to Arras*, written during the shattering days of the Second World War, he was able to transcend the calamity that claimed his own life in 1944. He exhorted his fellow humans to reflect upon civilization and to assume responsibility. During this ordeal, Antoine de Saint Exupéry felt that he was at one with France. But he also felt that France was responsible for the world it shared with others. His group – he served as an aeroplane pilot – volunteered for service elsewhere against aggression, in Norway and again in Finland. Each, they proclaimed, was responsible for all.

Today, as the world faces alarming shortages of water, we cannot afford to ignore this message from a man who gave his life to save the world in order to save France. We must begin, as Antoine de Saint Exupéry remarked:

> by recovering the animating power of our civilization which has become lost. That animating power is the power of hope, the power of joy; that we freely experience together as children in the river of life.

**Index entries:** history of water, dams, water crises, history of water management