

Water, civilizations and governance

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Abstract Water science, initially applied, has evolved in an interactive mode with civilization. Although it is difficult today to imagine civilization in a non-urban context, with the expansion of cities in the 20th century, civilization began in small groupings of families, in caves or other shelters. The disappearance of civilizations is usually on a secular scale similar to that of major droughts, which have tended to destroy purely agrarian societies. However, subsidies in industrialized countries, and technical progress have decreased such outcomes. Progress produces other problems such as in the construction of large dams, their societal and ecological effects, and sometimes of their rupture. Such catastrophes bring with them the pressures of global communication systems and of rumour. They also lead to criticism of engineers and scientists, who are increasingly pressurized to produce results of practical importance. Such a role of governance in water science is not always beneficial.

Key words Andes; China; civilizations; dams; disasters; Egypt; Mesopotamia; rivers; Rome; scientific progress

INTRODUCTION

One of the first historical references to water science in relation to governance is to the semi-legendary Chinese Emperor Yu the Great (about 4200–4000 years ago), who “mastered the waters” of the Yangtze and is considered to be the patron of hydraulic engineers. Some attempts have been made to date the beginning of civilization, but inasmuch as it involves a series of processes, many unrecorded, from animal-like simian ancestors to the present, but this has so far proved impossible. However, some authors link it to the beginnings of collections of man-made shelters and of primitive, sometimes irrigated, agriculture and as populations grew, irrigation became more and more important and widespread. It seems probable that some of the first rules of governance were linked to water use and the protection of water quality, as the size of communities grew and pressures on free access to water increased. This led to the introduction of channels and pipes and later to methods for measuring the amount of water delivered. With the growth of civilization the Earth became divided into territories, nations and States. Today there are more than 200 international river basins, some of which are a cause for conflict; especially when upstream States divert or store water affecting downstream flow rates, or when downstream States are more powerful than upstream ones. Commercialization of water and projects such as the Global Water System Project are likely to not only affect the independence of hydraulic engineers, but also the independence of hydrologists and other scientists.

THE RISE OF CIVILIZATION IN RURAL AND URBAN AREAS

Although there is a tendency today to associate civilization with urban complexes, it began with the first groupings of hunters, fishers and nomads. Today such groups continue to exist in extreme environments such as hot and cold deserts and high mountain areas: a demonstration of how human beings are able to adapt.

However, the major advances have come from large groups in urban areas which have evolved with human ability to harness water and to convey it to where it is most needed. With this ability has come the growth of cities and of water use/abuse. The recorded beginnings of urban civilization started about 6000 years ago in Sumer. A study of these historical civilizations shows that they initially evolved in proximity to rivers or lakes. Several authors have linked rivers in tandem with civilizations: China–Yangtze, Egypt–Nile, Harrapa–Indus, Mesopotamia–Euphrates and Tigris (Garbrecht, 1987; Viollet, 2000), but some, such as the Tiwanaku–Lake Titicaca, are less often cited. With these civilizations, except for Tiwanaku, writing began to evolve and the first written records of civilization along with hydraulics and applied hydrology (the nilometers 4500–4000 years ago).

In *De Aquis Urbis Romae* Frontinus, chairman of the Roman water supply administration (AD 97–103), indicated that for about four and a half centuries the people were satisfied with the water drawn from the Tiber, but then aqueducts had to be built to carry water to the city (Garbrecht, 1987). He also drew attention to the adjutages that assisted the authorities in calculating the amount of water delivered. He associated his Emperor Nerva (AD 96–98) with plans that led to the improvements in the day-to-day health of the people and the cleanliness of the city: an early example of the role of governance in water science.

History shows that the control of water and of water works has served different purposes, sometimes utilitarian, sometimes for pleasure, sport, etc. The use of water was fundamental in the early measurement of time, an essential for governance, with clepsydra or water clocks which were invented independently in Mesopotamia and Egypt (about 4000 years ago).

Since historical times water has had a role in purification and as civilization and religions have developed, so have their interactions with water science. Water in the form of the Great Flood was believed to have purified the Earth and today, water continues to play a special role in some religions from birth and baptism to death. One should not ignore the role of the religious hierarchy in governance and, in historical times, in the special uses of water.

The influence and size of towns and cities governs the major use of water in civilizations and empires. Urban authorities play a major role in decisions on water use, but the main part is always used in agriculture. When these empires cease to exist, because of natural or human events, the sophisticated systems of irrigation and of water conveyance disappear or fall out of use: sometimes to be renovated several hundreds of years later, as with khanats today.

ROLE OF WATER IN THE DEVELOPMENT AND DISAPPEARANCE OF CIVILIZATION

As indicated earlier water has played a fundamental role in the development of civilization(s). It still plays an important role today, which is why there are frequent

suggestions for the development of projects to transport water from a region where water is plentiful to one where it is sparse, often without sufficient consideration of the ecological, hydrological and meteorological effects at both ends of the transfer. One is tempted to ask: Can humankind learn from real or potential ecological disasters? The political effects of the *Nuclear Winter* study of the Scientific Committee on Problems of the Environment SCOPE (1985–1986), give us some hope. The water–civilization interface is still important today. In 2002, six of the ten largest natural catastrophes were floods and of the ten catastrophes with greatest economic losses, four were floods and two droughts accounting for about 75% of more than 42 000 million US\$ lost (Cornford, 2003). However, there has been a slight tendency to decrease over recent years as mitigation measures have an effect and as systems of international assistance become more efficacious. Over time a number of American civilizations such as those of the Maya, Mochica, Tiwanaku, etc. have disappeared and these have led to studies with varying, occasionally opposing, explanations.

The archaeologist Posnansky (1911) considered that Tiwanaku centre (10th/7th centuries BC to AD 10th/13th centuries) on the banks of Lake Titicaca had been submerged by the waters of the lake during a flood. Eighty years later Ortloff & Kolata (1993) put forward as the reason for the disappearance of this civilization a long drought in the 11th to the 14th centuries, based on the reconstruction of the climate made using ice cores from Peruvian glaciers. The lack of water caused the originally abundant agricultural production, on which the civilization was based, to decrease. So in less than a century both drought and floods have been put forward as reasons for the disappearance of a civilization. However, we can expect that the comparatively new discipline of paleoclimatology will lead to some improvements in our knowledge of past civilizations and their development and disappearance. However, it is difficult to imagine that the disappearance of one town or city can lead to the disappearance of a civilization. For example, the disappearance of Pompei and Herculaneum in AD 79 did not lead to the disappearance of the Roman civilization. Some archaeologists and climatologists tend to grant climate an over-exalted role in the stability of civilizations, especially those that developed in “marginal” environments (with little precipitation, low or high temperatures or at high altitude) which place constraints on the development of a civilization (Weiss & Bradley, 2001). Certainly the El Niño/La Niña episodes have played a negative role, especially in Southern and Central America, in restraining the rapidity of cultural development. Although the Little Ice Age led to the withdrawal of the Vikings from Greenland, it did not end their civilization. On the other hand it seems probable that the Easter Island civilization became extinct because of population pressure on the limited natural resources.

WATER SCIENCE AND MODERN CIVILIZATION

Civilization and water science are both affected by the growth of communication. Initially there were positive effects of transmission of information: (a) about the growth of civilization and the interactions between different cultures; and (b) about developments in hydrology and hydraulics. With the explosion of information on-line has come not only an increase in the amount of information available but also the problem of selecting it and its verification. It is well known that different sites on the

World Wide Web provide access to general and scientific information, but no indication of its reliability.

With the general information one has to take care to eliminate the effects of exaggeration and error. For example the catastrophe of Potosi (the Andes) in 1626 was responsible for about 2000 deaths (Gioda *et al.*, 2002) which was magnified to 4000 following a study by Rudolph published in 1936 and his estimation has been copied and recopied by several authors such as Jansen (1980) and Schnitter (1994), without checking the original sources and looking for advances in Latin American history (Fig. 1). The rupture of the dam at Vaiont in the north of Italy in 1963 was responsible for 2060 deaths, but because of a printer's error this became 2600 (Jansen,

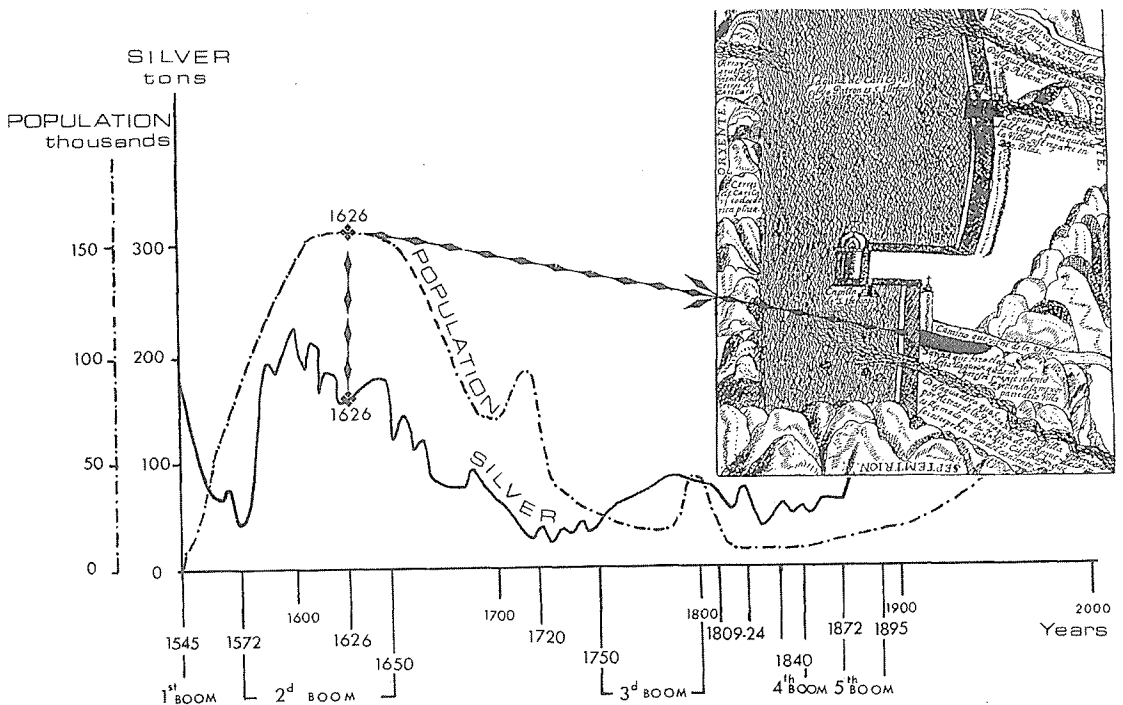


Fig. 1 Rise and fall of the silver city: Potosi (the Andes). The clearly seen second boom was made necessary by the need of the amalgamation process for large amounts of water and therefore of dams. The catastrophe of 1626 (approximately 2000 victims) is not visible on the population curve because there were about 150 000 inhabitants at that time and the loss represented only 1.3% of the population. The traces of the catastrophe were still visible 75 years later, as can be seen on the drawing by Arzáns by the black line below the dam rebuilt in 1628. However, production in 1626 was greater than the preceding year, but in general it had been decreasing progressively since 1605. The decline of Potosi was caused first by the competition from Mexican-made silver and then to the end of the supply of cheap mercury from Peru. It would therefore be erroneous to indicate today that "Potosi never completely recovered from the disaster" (Schnitter, 1994) and still less that "The town of Potosi had suffered irreparable damage" (Jansen, 1980). With regard to the governor, the *corregidor*, who had refused to lower the water level of the lake and was therefore responsible for the catastrophe; he remained in office without any difficulty until the end of his mandate in 1628. As to the Viceroy of the Indes in Lima he proved his efficiency by rapidly re-establishing the production of silver.

1980), a figure which is in general use in place of the correct one. One of the most recent disasters is that of Nîmes in the south of France on 3 October 1998. The number of deaths was initially given as 200 but as time passed the official figure was reduced to nine, but more than 1300 cars and 50 buses were submerged and 90 km of sewers were blocked or destroyed (Anonymous, 1989; M. Debordes, University of Montpellier II, personal communication). There is of course an attempt to profit from such exaggerations on the part of officialdom to benefit to the maximum from State or regional help and on the part of the individual to claim the maximum compensation from insurance companies. The poor, especially in the developing countries, must recover from disasters as best they can. The adaptation to catastrophes appears to be less and less evident in industrialized civilization (Weiss & Bradley, 2001).

Time tends to erase the memory of such catastrophes, as can be seen by some of the reactions to the recent drought in Europe. From reports in the media the current drought would seem to be unique. Following a big event le Centre de Création Industrielle organized an exhibition in Paris in 1980: *Le fil de l'eau*, "Heat wave, prairies dried up, water rationed. During 1976 the French people discover drought. What was thought to be reserved for Africa and Asia astonishes the French. The evolution of our civilization should lead the managers of water to modify the conception and size of infrastructures as well as rules for their operation. We no longer accept, psychologically, insufficiencies in the distribution of drinking water!" The author of the exhibition drew attention to the effects of drought and of the shortness of the period of weather prediction.

There is no mention of the need to use less water. Tow icebergs from the Antarctic, pipe water from the north or the east, drill boreholes deeper and deeper, but nothing about the need not to exceed the carrying capacity of the natural ecosystem. However, Lundqvist (1996) comes to the point after indicating that "industrialization and civilization have increased the human per capita influence... The quicker the population grows, the more disastrous are the environmental effect... Reduction of the population to a level where it can exist in harmony with the environment is the only way to a sustainable world".

PROGRESS IN WATER SCIENCE AND CIVILIZATION

Epicurus (341–270 BC) suggested that science was a fundamental aspect of culture, could help free society from superstition and tyranny and is an active element in social conflicts and therefore in the struggle for power. Even at this period of civilization views differed. Aristotle (384–322 BC), a contemporary of Epicurus, was probably the first to identify features that were common to both nature and politics. He is better known to the water science community for his erroneous views on the origin of rain that persisted for almost 2000 years until Pierre Perrault in 1674 wrote the first book on scientific hydrology: *De l'origine des fontaines*.

Science and scientists for several centuries were considered an exclusive part of civilization and less subject to pressures of governance from political and other leaders and more isolated from certain ethical pressures until the 20th century. In the last century however pure scientists are being forced by political and other groups to be more sensitive to both ethical and economic issues: a difficult task, made more

difficult by the disillusionment with science after the explosion of the first atomic bomb and some of the applications of science in agriculture, nutrition and health. Water science has been affected to a lesser extent but occasionally the results of catastrophes or carelessness are beyond concealment (Ackerman *et al.*, 1973). A recent case was the failure in 1998 of the Aznalcollar tailings dam in the region of the Donana National Park in Spain. Designated by UNESCO an International Biosphere Reserve in 1980 and put on the World Heritage List in 1994, the Park was nonetheless affected by some of the 5 million cubic metres of metallic slurry released by the rupture of the dam (García-Guinea *et al.*, 1998). In spite of such events water science tends to be in good standing and hydrologists are less subject to the pressures of today's civilization. However, economic pressures are more and more prevalent and one should not overlook a comment of Lovelock (1998): "Sadly science is no longer a calling where scientists are the guardians of knowledge, but has become a narrowly specialized employment". As scientists we have to find again *Paradise Lost* or as engineers seek *Paradise Regained* following Milton's quest (Gioda, 1999).

CONCLUSIONS

"Is water the basis of civilization?" "Yes—because without water there would be no life as we know it and therefore no possibility for civilization to develop". "Is water science the basis of civilization?" "Yes, especially for water scientists because it is their major interest and source of livelihood". However, care should be taken because there can be a conflict between the two with a loss of independence caused by the need to survive in the conditions of today with research budgets often tied to the need for results of practical and/or commercial importance. Returning to Yu the Great: according to legend Yu made an alliance with the God of the Yangtze and in order to be able to control the waters gave up half of his body as a pledge of his good faith. Having directed the water of the Yangtze to the sea, he re-organized the world limping, as a hemipelegic, across it in all directions. The legend does not indicate how Yu ended his "bargain" but it suggests that we should be careful in whom we pledge even half of our bodies and minds.

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