WATER MANAGEMENT - BASIS FOR THE DEVELOPMENT OF SETTLEMENTS SINCE PREHISTORIC TIMES?

Dr. Henning Fahlbusch[1]

Water characterizes the "blue planet". It is the basis of life, the life of plants, animals and mankind. The water is unequally distributed on the earth in the framework of the hydrological cycle locally as well as temporally. And when we consider the meaning of water for humans in history the discussion must focus on water itself. The engineering structures and technical elements are nothing but a necessary consequence for the management of water resources.

AVAILABLE WATER SUPPLY AND WATER REQUIREMENTS

The water that is available for living precipitates to earth as rain, dew, snow etc. Partly it percolates into the soil and seeps to the underground water. Another part will be collected on the surface in puddles, ponds or lakes or it flows in rills, brooks or rivers towards the sea. Surface water and ground water are the only natural resources available for use by living beings because the part that evaporates is not usable.

Plants are locally fixed and therefore depend on the locally available supply. Animals and humans on the other hand are mobile and can move to where the water is available. This behaviour probably dominated the early humans such as nomadic hunter-gatherers, but we still observe this phenomenon in the case of Bedouins.

However, after the humans settled down the need for a regular supply of water grew. This was possible easily from perennial rivers or lakes and/or at some places from springs. When there was sufficient or even abundant water cultures could develop, as for instance in the river valleys of the Nile, Euphrates/Tigris, Indus, or Hoang Ho. These cultures which depended on the water in the rivers are therefore often called "hydraulic civilizations".

Since early times humans were confronted with the natural hazards of droughts and floods. Both threatened people, as we can read not only in the Bible but in many other reports from various parts of the world. And people had to overcome both these situations. To achieve this structural measures were necessary which were more or less copied from nature and then developed and improved. Nature was the teacher in antiquity. In the following text measures for the supply shall be dealt with first, and afterwards those for flood protection.

1- Vice chairman of German Water History Association and former ICID Member. Email: fahlbusch@fh-luebeck.de

In the beginning, water requirements were confined directly to the supply of drinking water for humans and animals. After people settled down and developed a more complex society, water requirements increased to include also hygienic and ritual washing, water games, cooling and the use of water power as well as navigation. Often the local water supply became insufficient for these various purposes and the need for water resources management developed.

WATER RESOURCES MANAGEMENT – TRANSFERS

With regard to the supply of water there are in principle two problems: one of quantity and one of quality (hygiene, salt content, bitter taste, temperature etc.). The problem of quantity was regarded as more important. As already mentioned, from the beginning humans used surface or spring water for their supply. The latter was certainly better from the hygienic point of view, but its quantity was, and is, generally limited. Thus underground water could only be made accessible by wells, and this was already done very early on.

When water requirements exceeded the locally available supply there are only two manmade measures available to meet the demand: temporal transfer and local transfer, or a combination of both these methods. Local transfer of water involves its transport in aqueducts from the origin to the place of demand; whilst temporal transfer involves its storage in times of surplus to be used at times of insufficient supply.

Nature was the model for the builders of storage facilities as well as for aqueducts. Both types of transfers have already been used since very early on. The builders constructed the necessary hydraulic structures only after thorough studies and analysis of the local natural conditions to which they were excellently adapted. Their improvement was surely based on the principle of trial and error.

THE SUMERIAN MYTH OF CREATION

A Sumerian myth of creation, which can probably be dated to the 3rd millennium BC (Bagg 2004) shows, that already more than 4000 years ago the climate in Mesopotamia was arid or semiarid because agricultural production already depended on irrigation. To achieve this, the backing up and storage of water, as well as its conveyance, were common practices. The translation of the relevant text by Pettinato reads:

… nobody cleaned the small canals;

Nobody removed the sediments from them;

Nobody irrigated the good fields;

Somebody, who dug irrigation ditches, was not available;

…….

…. Ninurta, the son of Enlil, did great things:

He built a big mass of stones in the mountains;

….

He constructed a barrier at the horizon;

….

The stones struggled with the powerful water;

Now the water of the mountains will not flow down to the valley any more;

(the waters) which were scattered he collected,

(the waters) which were lost in the mountains

he collected and pitched (them) into the Tigris,

early flooding he poured onto the fields.

……..

Engineers cannot comment on this translation. But the interpretation of Pettinato is logical that the text says, that the god Ninurta collected the water of the Tigris by means of a huge dam which stored it and thus tamed it. The stored water was used to overcome droughts. The need for temporal as well as local transfer was obviously common knowledge at that time.

TEMPORAL TRANSFER BY MEANS OF DAMS AND CISTERNS

The oldest dam of the world known to us was obviously constructed in the same epoch in which the quoted Sumerian myth of creation was written. It is a dam 5 m in height and 80 m in length at Tel Jawa in the desert of northern Jordan (fig. 1). The dam was constructed from two walls made of basalt-stones and a core in between of ashes and soil. Together with three additional ponds the whole system could store about 42000 m³ of water (Vogel 1991). The discharge after the heavy wintry rainfalls in the catchment area of the wadi was stored there. This was the source of the water supply for the people of Jawa in the desert.

Figure 1: The old dam at Jawa

The example of the dam at Jawa shows that it was already possible to construct high, long and obviously expensive dams during the bronze-age. However, such a big thoroughly planned structure was surely not constructed as a new design but would have been the result of a long development process. But this we do not know. How was it initiated?

When Darwin proposes that the human embryo repeats the historical development of the human species, it can be supposed that children might also perform the cultural development of mankind. Every child coming to a brook immediately starts to play there. And when playing he will start to back up the flowing water. Is it instinct?

Surely the first dams were of low height and of short length. They could not be confirmed archaeologically yet. But surely they did exist. But in the course of centuries and millennia they would have been demolished by nature and men.

The various types of dam construction were improved in the course of time, especially by the use of ashlars. Small valleys were closed at very many places in order to create basins for the storage of water. In Petra (Jordan) for instance small walls can be seen in narrow side gorges (fig. 2) when one walks through the main gorge, the Siq, into the old Nabataean capital. Behind these walls water was trapped and stored and at the same time the threats of floods decreased.

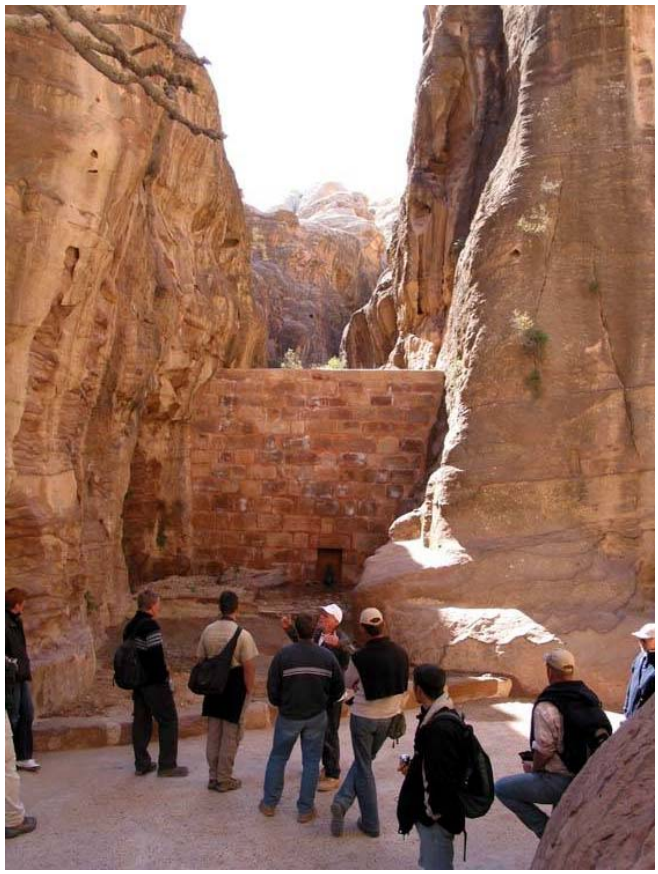

Figure 2: Reconstructed dam in a side gorge of the Siq in Petra (Jordan)

Water in open ponds stored by means of dams is not perfect from the hygienic aspect. Pathogens can easily develop there. This is not the case in closed, covered cisterns because of the darkness and the lack of organic material for the supply of bacteria. Additionally, the water in cisterns remains cool in summer in comparison to that from open ponds which are directly influenced by the sun. This is a very valuable advantage in quality as well as diminishing evaporation.

Cisterns were often directly cut into the rock and sealed by means of plaster to prevent seepage losses. Rainwater was then diverted into them and stored there. If the volume in the cistern amounted only to a few cubic meters, probably only single estates would have been supplied from it. Later people managed to construct large cavities with a volume of more than 100 m³, including the sealing of large clefts or caves in the rock in order to create huge underground storages. Examples for that can be found for instance in Beidras (Jordan) or at ancient Sepphoris (fig.3) in the Holy Land.

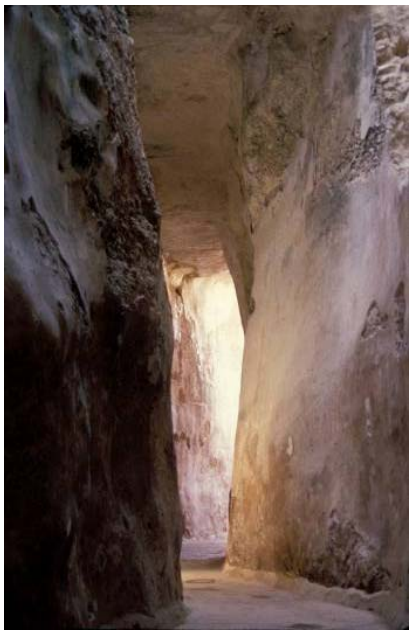

Figure 3: Cave used as huge cistern in antiquity at Sepphoris (Foto: Tsuk)

LOCAL TRANSFER BY MEANS OF AQUEDUCTS

The oldest long distance channels known to us are also already high quality engineering structures. The 54 km long Menua-canal in southeast Anatolia (Garbrecht 2004) as well as the 55 km long Jerwan-canal (Garbrecht 1985) in Iraq of today conveyed water mainly for irrigation. The discharge of the Menua-canal (fig. 4), of up to 8 m³/s was limited by the output of its spring. The discharge of the Jerwan-canal was probably much larger then 10 m³/s as its water was taken from the Gomel river. The discharge of these aqueducts far exceeded that of the famous Roman aqueducts. In one of its largest, the Aqua Claudia of Rome, not more than 1.5 m³/s flowed into the capital.

It can certainly be assumed also for the structures of the local transfer that such “world records” had not been created ad hoc but were the culmination of a long process of

development. But we do not know the details of this development, probably because all the elements of the early small structures have vanished in the course of time.

Besides some written sources like the text quoted above, sometimes traces are found already in prehistoric times of the human ability to direct water to a goal in a planned line. Such an example is the irrigation project of Tel Hujayrat-al-Ghuzlan near Aquaba in Jordan, which can be dated to the first half of the 4th millennium BC. Here artesian groundwater came to the surface most probably under the specific hydro-geological circumstances in a number of spots in a field of springs. Traces of calcareous crusts on the stones, so called sinter, prove that indeed ground water was used here, principally to supply the humans and their animals. Additional water however was diverted into a vast system of terraced fields for irrigation by means of conducting walls which were made of unhewn stones set into loam. The size of this system indicates that here agriculture was done on a large scale and was the source of the prosperity of the settlement (Grottker/Heemeier 2006). This in turn supported the further development of the hydraulic system.

Figure 4: The modern Menua-canal. Above it at the slope the retaining walls of the old structure can be seen (Foto: Garbrecht)

FLOOD PROTECTION

On initial consideration, flood protection seems to be unimportant in the arid region of the Near East. However, this is not true, at least not for Mesopotamia. The requirement for dikes and their maintenance is already mentioned on the stele of laws from Hamurabbi (about 1700 BC). Law 53 reads:

“In case somebody is too lazy to maintain his dike in good order and in case this dike fails and all fields are inundated then this person in whose reach the failure occurred shall be sold …”

Every year after the melting of the snow in the upper reaches there was the permanent threat of inundation in spring in the vast plains of the Euphrates and Tigris. This threat required great flood protection measures not only for the settlements but also for the fields. Therefore many dikes were constructed.

Another example of flood protection measures can be seen in the Siq gorge in Petra (Jordan) mentioned above. In 1926 a group of visitors drowned there after a heavy thunderstorm. As a consequence the ancient flood protection system was rebuilt. This consists of a dam which prevents the water from Wadi Musa entering the Siq. Instead the flood will flow through a tunnel into a neighbouring wadi thus bypassing the vulnerable part. Furthermore, the walls in the side gorges of the Siq mentioned above ensured that no flash floods could develop along the vital access route to the Nabataean capital.

However, the peculiarity of Petra's flood protection measures is, that it was integrated into the whole water management system. Every drop of water available, either as ground water or surface water coming from precipitation, was collected, cleaned, stored and finally used (Bellwald 2003). Therefore it is justified to call Petra a water-managed-desert-city.

The question in the headline of this paper whether water was the basis for the development of settlements can at least for Petra be nothing but assented to.

SOCIETY

It was explained before that the principal methods of water management are as old as the history of mankind. The people more or less imitated nature. Technical developments concerning the number and quality of the necessary structures were made possible by the technical skills of artisans who used natural materials after thorough studies and analysis of their characteristics.

But huge structures would not have been built based on technical skills alone. The great innovation was principally the logistic and organisational coordination of the work of hundreds or even thousands of people to realize gigantic projects for that time. The masses of soil to be moved for dams, and dikes, or the many kilometre long canals could not be performed by the inhabitants of single villages. Furthermore there was the knowledge that the newly built structures had to be maintained and if necessary to be repaired. This required not only competence and organisation but also rules and regulations which were commonly accepted. And this was obviously the case when one looks once more at the stele of Hamurabbi, for instance.

OUTLOOK

When nearly 30 years ago here in Teheran Prof. Garbrecht successfully suggested to set up a Working Group on History in the ICID-family it was done with the understanding that even engineers in the 20th century can learn from history. And naturally this was therefore the topic of many sessions which were organized in the past at ICID-meetings. But these were always reports of single projects which many scholars had investigated.

Five years ago the German Water History Association (DWhG) was founded, which has close relations with WG-HIST of ICID from its beginning. Now the DWhG hopes to start a bigger research project supported by one of the largest German Research Centres. The aim is to recreate ancient structures and technologies especially in areas where scattered estates lack water and cannot be included into a public supply system.

In this context it is unquestionable that modern materials for aqueducts are by far superior compared to those used in antiquity. However, can they always be financed? And what about dams? Large dams are already a focus for critics since long ago, especially in developing countries. Small scale storage facilities are often better adapted to the requirements of the people. Probably there are also problems of acceptability. A recent publication in Israel shows that in the northern part of that country many people, especially Arabs, use cisterns instead of the public water supply system although it is more expensive. And they are even constructing new cisterns. The reason is that thus they gain a larger security for their independent supply.

Another recent study of cisterns in Umm Quais in northern Jordan shows that cisterns were still used there until 20 years ago. In 1987 their operation was stopped. Why? It needs little effort just to clean and reuse them in order to collect water in winter, when it would otherwise flow unused to the valley. The same applies to a big pond in Beidras in Jordan (fig. 5), for instance. Obviously the ancient walls are still strong. They just would have to be cleaned and newly plastered to become impermeable. Thus about 10000 m³ of additional water could be used at this place. But today it is no more than a garden. The reuse of these structures could be the beginning of a reinvention of old techniques and structure in this wonderful country.

Here mostly the examples of Jordan were mentioned. But surely the situation in many other countries is similar. The German Water History association likes to invite you for cooperation at similar projects in your respective country.

Figure 5: Ancient pond as garden in Beidras (Jordan)

BIBLIOGRAPHY:

1. Bagg. A.: Personal communication 2004
2. Bellwald U.: The Petra Siq – Nabatean Hydrology Uncovered, Amman 2003
3. Garbrecht G.: Wasser –Vorrat, Bedarf Nutzung in Geschichte und Gegenwart, München 1985
4. Garbrecht G.: Historische Wasserbauten in Ost-Anatolien in: Ohlig Chr. (ed.): Wasserbauten im Königreich Urartu, Schriften der DWhG, Band 5, Siegburg 2004
5. Grottker M. and Heemeier H.: personal communication 2006
6. Keilholz P.: Wasserwirtschaftliche Anlagen des antiken Gadara/Umm Quais, Dipl.-Arbeit and der FH Lübeck, unpublished, Lübeck 2006
7. Pettinato G.: Das altorientalische Menschenbild und die sumerischen und akkadischen Schöpfungsmythen. Heidelberg 1971
8. Vogel A.: Die kupferzeitlichen Dämme von Jawa in Jordanien in: DVWK (ed.): Historische Talsperren 2, Stuttgart 1991