THE MANAGEMENT OF WATER RESOURCES AROUND THE WORLD: A REVIEW

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ABSTRACT

Water resources are unevenly distributed in time and space. They must be managed in order to control the presence of water on Earth. This is what this paper deals with. The paper gives a review of management of water resources in some countries, namely: Turkey, Japan, Netherlands, India, Italy and China. It is concluded that different countries use different methods and technics to manage water resources. Some of them are still useful, although are quite old, but there are also modern methods. Large cities are particularly vulnerable to flooding due to their huge concrete structures with a lack of green areas to absorb rain. As a result, floods remain a central sore point for most of them.

Keywords: Water resources, Management, City, Flood, Future Cities

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1. INTRODUCTION

Water is one of the essential elements for the existence on the Earth. The greatest part of the Earth consists of water. Despite this fact, the lack of drinking water still remains the main problem for many people. While, on the other hand, floods are common occurrence in numerous countries. As a matter of fact, water resources must be managed to prevent the above phenomena and to be used for many purposes to fulfil the needs of people and nature: for drinking, for hygiene, for production of electricity, for irrigation of agricultural land, parks and other green areas, and so on. Different systems are used to provide clean water for drinking. Some other systems are used to take away the storm water and sewage, totally different systems are used for irrigation, etc. Also, different techniques are used to manage water resources in urban areas. The following case studies are some examples of construction projects related to water resources management in urban areas, i.e. the aim of this study is to give a review how the management of water resources is done in some countries around the world, namely: Turkey, Japan, Netherland, India, Italy and China.

2. THE MANAGEMENT OF WATER RESOURCES

2.1. Turkey: Basilica Cistern, Istanbul

This ancient underground water cistern was the largest water reservoir in Constantinople (today Istanbul) and is known as the Submerged Cistern "Yerebatan Sarnici". The water in the tank was transported from the Belgrade (Serbia) forest from the huge Byzantine aqueducts. It was unusable for some time, but was discovered by the Frenchman Petrus Gyllius in 1545 [Istanbultourstudio.com, 2019]. It represents the largest underground tank in Turkey with dimensions 140m x 70m with a capacity to hold 80,000m^3. Due to its underground construction, the roof of the tank is retained over 336 marble pillars 9 meters high. The columns are arranged in 12 rows with 38 columns, 4.9 m apart [Mays, Antoniou and Angelakis, 2013]. 52 stairs lead to the cistern which is surrounded by walls and connected to an aqueduct that distributes water [DGM Magazine, 2019]. Today the tank is not used and there is very little water. But the cistern is used as a tourist attraction, museum, event venue and so on.

Fig 1. and **Fig 2.** The Basilica of Constantinople

Source: [Mays and al.,2013; DGM Magazine, 2019]

2.2. Turkey: Melen System, Istanbul

Istanbul is one of the most populated cities in the world. Furthermore, its population is growing everyday as result of a large in-migration. Therefore, water supply and sanitation are major concern of the city [van Leeuwen and Sjerps, 2015]. In order to provide water to Istanbul the Melen watershed was constructed, located in the western part of the Black Sea Region and 180 km to the east of Istanbul. The water from Asian side (Melen River) is transfered to Euporean side (Istanbul) by a 6-m diameter and 5551-m long Bosphorous tunnel [Inc., 2019]. The tunnel goes 135 m below sea level, crossing the two continents, with a capacity to transfer 3 million m3 of water daily [Cuceloglu, Abbaspour and Ozturk, 2017]. This project will transform the Melen River Basin into Istanbul's most important water source. The Melen Project aims to solve the problem of drought in Istanbul until the year 2071. It consists of variety of components; the Melen Dam, Melen regulator, a drinking water treatment plant and a 189 km pipeline, as shown in Figure 1 [Ağıralioğlu and Danandeh Mehr, 2019].

Fig 3. Melen Dam basin **Source:** [Inc., 2019] **Fig 4.** Pumping station **Source:** [Inc., 2019]

2.3. Japan: Metropolitan Area Outer Underground Discharge Channel, Tokyo

With the construction of the gigantic underground flood system which lasted over the course of approximately 17 years, Tokyo has decided to tackle the issue of flooding quite seriously [McFadden et al., 2019]. The region of the city of Tokyo is located on an alluvial floodplain with eight major rivers that flow through the Tokyo Basin. Since flooding is a major concern in Japan, the country has a long history of managing water resources, river diversions and flooding [Dunlop, 2015].

To protect the country from flooding, Tokyo has built the largest stormwater-drain in the world, the Metropolitan Outer Area Underground Discharge Channel. It eases overflowing of the city's major waterways and rivers during rain and typhoon seasons. The famous Metropolitan Area Outer Underground Discharge Channel is a flood prevention facility located in Kasukabe city in Saitama, 19 miles north of Tokyo, Japan. It is often called "the Underground Parthenon" or "the Underground Temple" [Naho, 2019]. It was built 22 meters below ground level between 1993 and 2009, with the dimensions: 177 m long, 78 m wide, 25 m high with a forest of 59 reinforced concrete pillars each weighing 500 tons supporting the ceiling. The main tank known as the "Underground Temple," resembles a sort of bizarre underground cathedral [Nagy, 2015]. The construction is gigantic. In its compound are included gargantuan tunnels, colossal water tanks, massive pillars and enormous pumps. The 78 water pumps in the humongous drainage system can pump over 200 tons of water per second [Nagy, 2015]. The facility has the capacity to protect from historic flood, the kind that only comes every 200 years [Dunlop, 2015].

Fig 5. The pillars **Source:** [Nagy, 2015] **Fig 6.** The pumps **Source:** [Web-japan, 2013]

2.4. Netherlands: Maeslant barrier, Rotterdam

The Netherlands is located at the end of the Rhine, the largest river in Europe [Silva, Dijkman and Loucks, 2004]. Much of the Netherlands is below sea level, so the country has been facing major floods for hundreds of years. Hundreds of years ago, the Netherlands had a vast history of storm floods that resulted in hundreds of thousands of deaths. For this reason, the Dutch have become the best water management experts in the world, turning the Netherlands into a water-focused economy. Of the many flood solutions, the most famous is the huge Maeslant barrier, against a flood gate the size of two Eiffel Towers. It is a computer-controlled storm barrier that closes automatically when Rotterdam is threatened with flooding. First, the dry ports were constructed on both shores, and then the two steel gates with dimensions of 22m high and 210m long were built [Wermac, 2019]. Sea level is monitored by computer, and the port can be automatically opened or closed in two and a half hours. When the hands of the gate are closed, they meet and lock, and the pipes are filled with water and lie on a concrete base, creating an impenetrable steel wall. The pressure from the sea is transmitted from the steel wall to the largest ball joints in the world, inserted in the banks on both sides of the river. When the gate is reopened, thirty pumps draw water from the pipes. If the grid fails, there is a backup network and, as a last resort, a generator [Thestructuralengineer, 2019]. The frequency of floods in Rotterdam is effectively reduced by a controlled barrier [Zhong et al., 2012], which serves as a good example of total flood.

 

Fig 7. and **Fig 8.** Maeslant barrier **Source:** [Wermac, 2019]

2.5. India: Water temples

India is the country that receives the heaviest rainfall in the world, and on the other hand suffers from water shortages every year in periods when there is no rain. Due to the spatial and temporal variation of precipitation, the country is facing the sixth outbreak of floods and droughts [Kumar, Singh and Sharma, 2005]. Water resources management is done with traditional methods that have been used successfully since ancient times. Each region has its own unique system for water supply or water collection. Basically, these systems are in the form of tanks of two types; one is the village tanks, which serve for daily needs and temples that served the vital purpose, for refilling the groundwater [Kaptan, 2019]. Traditionally, temple reservoirs have played three or three hydraulic roles: to store water as insurance against periods of low rainfall, to protect against floods during periods of heavy rainfall, and as a key tool for overall ecosystems [Ganesan, 2005]. The temple reservoirs of India are ancient water bodies that are an integral part of the temples. Temple tanks, in orthogonal projection are either square or rectangular and in cross section have the shape of a trapezoid, narrowing upwards. Usually temples consist of two tanks, an inner and an outer one. Granite is used in the construction of the stairs. Most tanks have wells in the ground. The wells connect the aquifer and the reservoirs and serve for natural filling [Alaguraj, Divyapriya and Lalitha, 2017], so the reservoir design is ideal for collecting and storing rainwater.

 

Fig 9. Chand Baoli, Dausa **Source:** [Pursuitias, 2018] **Fig 10.** View of the temple tank **Source:** [Alaguraj, et.al., 2017]

2.6. Italy: Moses Floods Barriers, Venice

A similar example as the Barrier in the Netherlands is the barrier in Venice, Italy. Venice is built on the islands and swamps of what is now known as the Venetian Lagoon. The Venetian lagoon, on the other hand, lies where rivers from mainland Italy empty into the North Adriatic Sea [D. Mitchell, 2017]. The Moses system was built to protect the country from flooding. It is located at the entrances to the lagoons of Lido, Malamoko and Kyogia, the three gates of the coastal cordon through which the tides spread from the Adriatic Sea to the Lagoon [Anon, 2019]. This system can protect the lagoon and its cities from the tides up to 3 m and will therefore be effective, even if sea levels rise significantly over the coming decades [Cecconi, 2013]. Moses is made up of four barriers; two at the entrance to Lido, consisting of 21 gates respectively, one barrier formed by 19 gates at the port of Malamoko and one barrier formed by 18 gates at the port of Chiogia. When inactive, flood gates are filled with water and lie completely invisible. In case of danger of floods, air enters the barrier channels and empties them of water. As water exits the gates, they rise and block the flow of incoming tide into the lagoon. Each gate is composed of a metal structure in the form of a box. The width of the gates is 20 m and each of them has a different length proportional to the depth of the place where it is installed. The average closing time of port entrances is about 4-5 hours [Anon, 2019].

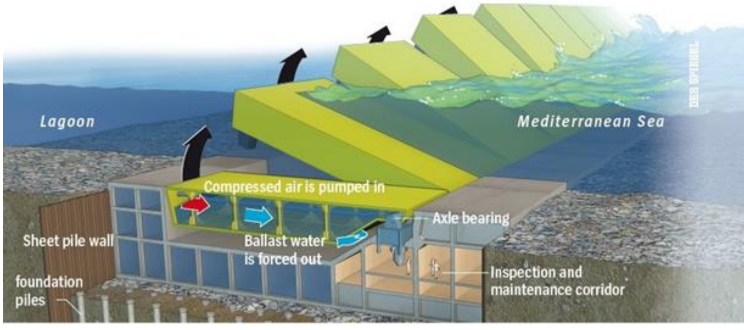

Fig 11. and **Fig 12.** Moses Floods Barriers Source: [Venice flood barriers pass first test, 2020]

2.7. China

Researchs so far show that 62% of Chinese cities have experienced floods. , so the concept of Sponge Cities was introduced in 2014, which will be used to deal with floods and surface water in urban areas [Chan et al., 2018]. The goals of Chinese sponge cities are: to retain 70-90% of the average annual rainwater on site by applying the concept of green infrastructure, eliminating droughts and floods, improving urban water quality, mitigating the impacts on natural ecosystems, etc.

Sponge cities are cities that easily adapt to changes in the environment, in some way function as a sponge, ie, absorb, purify rainwater and copy stored water when needed [Shao et al., 2016]. Seven key synonyms would provide an accurate explanation of the term 'Sponge Cities'; "Sustainable Urban Water Management (SUWM)", "Integrated Urban Drainage System (IUDS)", "Water Sensitivity Urban Design - WSUD", " Low Impact Development (LID), Active Beautiful Clean (ABC) Waters Program and Sustainable Urban Drainage System (SUDS) [Li ID, Xu and

Yao, 2018]. The concept of sponge cities has four main principles, namely: urban water resources, environmental water management, green infrastructure and urban absorbing roads [Nguyen et al., 2019]. So, the concept of sponges is intended to change the way urban planning is promoted while promoting the inclusion of more green space in urban areas. With successful implementation, the concept will result in more efficient land use, increase of green areas, conservation of rivers, swamps and other city water bodies, control and storage of atmospheric water during extreme rain and so on [Chan et al., 2018]. This practice will ensure complete control of the environment. In addition, the idea of sponge cities includes renovating drainage systems, improving the connectivity of water systems, separating rainwater and sewage networks, which will improve the city's ability to deal with water problems [Liu, Jia and Niu, 2017]. By building this type of cities, it is expected to achieve integrated rainwater management, flood protection, and its use during droughts. The city sponge program will also create investment opportunities in infrastructure upgrades, engineering products and new green technologies [Li et al., 2017]. As a new approach to urban water planning and management, the Chinese sponge town-building initiative is entering its fourth year and is rapidly adapting to cities across the country. In the Shanghai area, in Lingang, wide streets with ventilated sidewalks are being built to allow rainwater to seep into the soil beneath them. Roof green space is increased and water tanks are placed above the buildings to prevent flooding and collect more water for reuse [Zengkun, 2019]. China's experiences can be useful to other countries and cities, especially as it progresses in its international infrastructure project.

Fig 13. Schematic diagram of the concept of Sponge Cities **Source:** [Chan et al., 2018]

Fig 14. View from Crane Tower in Wuhan **Sourse:** [Zengkun, 2019]

4. CONCLUSION

Any change made through the construction of facilities necessary for modern living, should be analyzed and preferably reduced to a minimum to maintain the natural regime of water and the environment in general. In this regard, it is necessary to work on the relationship of each individual with the natural environment and, in general, with the use of water, as a basic resource for the existence of flora and fauna, including man himself. From the given examples it can be notices than the water resources have been managed since ancient time. Some of the projects are made to bring water from certain places and some of them aim to protect a certain area from floods. These examples can serve as a bases for sustainable management of water resources for future cities. Sustainable management of water resources for future cities requires the participation of a team composed of different social and governmental groups, and the most important factor is to put certain people in appropriate places. It is a collaboration between government, academia, creatives and artists, advocates and residents. Involving the academic attitude in the process of water resources management means gaining time and effort. Research universities should be given the opportunity to put their ideas into practice. If we want to have a human-oriented human city, with proper water resources management, architects and planners must be part of this new approach. Their work covers another dimension of humanity without which the smart city would not be complete. Also, the developing countries should take example from developed countries, to manage the water resources in proper way. It would reduce time and energy.

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