SUPPLY AND CONSUMPTION MANAGEMENT IN MEGACITIES: EXPERIENCES RELATED TO MEGACITY OF TEHRAN

Sattar Mahmoudi, Tehran Water and Wastewater Company; Email: S-Mahmoudi@thr-ww.com

ABSTRACT

In this article, the current situation confronting the management of water resources in the megacity of Tehran is explored, including future challenges, and those policies undertaken to manage the challenges, in order to safeguard and promote the splendor and vitality of the mega city of Tehran.

Population growth, the creation of mega cities and increasing demand for water are some of the most serious challenges for the management of population centers in various countries. Most mega cities in the world are faced with multiple problems when it comes to improved management of water resources and the creation of safe cities, each having their own special experiences. Some of these experiences - which can be very expensive - can to some extent be of use in other mega cities.

Due to water crisis of 2001 and constant shortages of adequate volumes of water, the megacity of Tehran has gained some valuable experiences, which could be utilized for future planning. In this article, we hope we can properly express some of the experiences and views of water management in this mega city, so they can be of benefit to others.

Key Words: Consumption increase, Mega cities, Population increase, Scientific and practical approach, Water consumption management, Water resources limitations, Tehran Experiences.

INTRODUCTION

Population growth, development and the necessities of urbanization have made the creation of large and mega cities inevitable. At the beginning of twentieth century, the number of mega cities in the world was about ten, but now at the beginning of twenty-first century, this has increased to 65.

When considering mega cities, a range of efficient and non-efficient ways of managing them comes to mind, as mega cities contain simultaneous challenges and opportunities relating to public services, security, public health and the environment. Some mega cities can have enormous effects outside of their geographical boundaries, and in some cases, even outside of borders of the countries in which they are located. Therefore, paying attention to the various issues related to mega cities, particularly from an environmental and water resource management point of view, is extremely important.

This article thus examines supply and demand management of water resources in mega cities, with an emphasis on the location and experiences of Tehran. Many solutions and experiences gained and used from and during the process of facing these challenges, and also varied actions related to supply and demand management which were taken, can be utilized and applied to other mega cities and large cities in the world, especially developing countries of the middle east, because of their similarities in terms of social, geographical and climate conditions.
TEHRAN’S WATER SUPPLY AND CONSUMPTION MANAGEMENT

With more than seven million permanent residents and two million non–resident commuters, Tehran is the sole mega city in Iran, constituting the largest population base in Iran and the eighth largest city in the world. It could therefore be considered a miniature of Iran: in terms of its cultural diversity and other characteristics, it is replete with symbols and phenomenon from all corners of the country. Yet as a mega city, it is also an important political hub for high ranking decision makers in Iran and foreign embassies and enjoys freedom of the press and freedom of public opinion.

Almost 26 percent of all activities in the country related to the water and wastewater sector are conducted in Tehran. The city itself is also faced with serious water-related challenges as Tehran is not constructed close to any large river thus its water resources are very limited and consumption patterns are very high. Thus in addition to these challenges of water availability and consumption are added challenges of cyclicality of water and climate (drought and rainy seasons) and increasing numbers of people living in the city outskirts. Further, it has been noted that there is difficulty in meeting demands of public services at appropriate levels in terms of quality, customer rights and safety factors involved in their delivery. Thus there is also a need for increased inter-organizational cooperation for effective water and waste management.

In order to manage the water in this mega city, large investments of time and money have been spent to build the capacity of the city to manage its water resources effectively. Thus the experiences gained during the 2001 water crisis constitute a case study and have created an excellent opportunity to be able to predict and correct problems and devise effective solutions, both for periods of water shortage and general urban water consumption management. These experiences were gained at high costs and high social risks and demonstrate how serious problems related to the management of water in mega-cities can, in fact, threaten their long-term viability if solutions are not found. Thus, by sharing Tehran’s experiences it is anticipated that other mega cities, both regionally and globally, can potentially avoid the repetition of problems.

Some such challenges faced in Tehran include:
- limited water resources;
- spread of different pollutants threatening water resources;
- population growth and lack of a defined population ceiling;
- increased consumption and lack of planning or focus on consumption patterns and management;
- endless horizontal and vertical development (of people, city, etc);
- uncoordinated construction activities
- partially executed projects and accumulated expenses (impeding project completion);
- low water tariffs and limited financial resources
- increased industrial and urban wastewater and sewerage;
- a lack of new urban water telemetry and tele-control system capable of executing commands for supply cut-off, regulating distribution flows, and the distribution of urban water. The modern section of this system is ready for operation.

The biggest challenge faced by Tehran was the limited water resources. In 1931 when the population of the province of Tehran was less than one million, the amount of renewable water per capita was about 6000 m$^3$/year. Comparatively in 2004, for a population of 11 million, this number has dropped to about 500 m$^3$/year. By 2025, for a population of 15.5 million this figure will be reduced to 400 m$^3$/Year, highlighting the water supply crisis situation. These trends are demonstrated in the diagrams below.
One of the main reasons for the unsustainable water supply in Tehran is its cyclical dry and wet seasons. Based on statistics which exist for Tehran’s watershed area for the last 60 years, during 40 percent of this period Tehran was faced with drought. For a mega city like Tehran that has a huge and burgeoning population, this phenomenon is a serious challenge.
Modern and traditional living around the outskirts of Tehran, in the areas outside of legal city limits, creates additional challenges. But whereas ‘outskirts living’ often denotes huts, shanties and houses build without proper architecture, in Tehran, the reality is completely different: it means strong and engineered construction and rapid development. In Tehran’s outskirts, large engineered buildings have been built or are being built, supported by large investment, and continuous growth is anticipated. These trends are shown in the images below.

Figure 3: City expansion

![City expansion diagram](image)

- **Construction outside city limits**
- **New Regions of municipality of Tehran**

Figure 4: burgeoning population

Figure 5: more buildings at city limits
However, investors and property developers have apparently short-term visions with regards water supply and demand, precluding water management strategies from their developments and building construction building and thereby contributing to potential future water crises in Tehran. In order to be able to manage this challenge and to obtain more precise information, during 2003, the Tehran Province Water and Wastewater Company ordered aerial photographs to be taken of areas outside the city limits. The photographs were studied in detail and the information gained was transferred to maps. An analysis of these maps indicate that the total land being used outside the city limit is about 4000 hectares, and in the near future a population of close to one million will live there.

From an investment point of view, this will be very challenging, as estimates for the water and wastewater sector alone indicate that close to $66 million USD is needed to meet demands.

Thus, in summary, the problems associated with rapid urban development on the city outskirts of Tehran, and which are challenges faced by other mega cities, include:

- unpredicted expenses and unplanned changes to existing long-term planning;
- destruction of natural heritage and especially the northern plains of Tehran;
- environmental abuse and its consequences and that impede sustainable development;
- increase in population in Tehran, and population extension;
- lack of developed infrastructure and investment impeding buildings and constructions.

IMPORTANT WATER AND WASTWATER INDICATORS IN CITY OF TEHRAN

Currently, although 98.5 percent of Tehran’s population have access to safe drinking water, only about one tenth of them (9 percent) have access to proper discharge of the wastewater system. In 2021, these numbers will be around 100 percent and 60 percent respectively.

Table 1: Important Water and Wastewater Indicators in Mega City of Tehran

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Current condition</th>
<th>Year 2021</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population having access to safe drinking water</td>
<td>Percentages</td>
<td>98.5</td>
<td>100</td>
<td>1.5</td>
</tr>
<tr>
<td>Total number of water subscribers</td>
<td>1000</td>
<td>880</td>
<td>1100</td>
<td>220</td>
</tr>
<tr>
<td>Volume of water needed</td>
<td>Million cubic meters</td>
<td>920</td>
<td>1400</td>
<td>480</td>
</tr>
<tr>
<td>Population having access to modern wastewater discharge system</td>
<td>Percentage</td>
<td>9</td>
<td>60</td>
<td>51</td>
</tr>
</tbody>
</table>

CURRENT SITUATION OF WATER SUPPLY IN TEHRAN

In 1963, the total water supply capacity of Tehran was around 300 million cubic meters. This supply volume was 30 percent more than demand. In 1993, supply and demand reached equilibrium, but from 1996, shortages surfaced. It is therefore predicated that by 2021 water demand will have reached 1400 million cubic meters per year, which means 480 million cubic meters of more water will be needed.
In order to balance this situation, activities should continue in two areas, namely water supply and consumption management. The following sections elucidate these ideas.

**ACTIVITIES RELATED TO WATER SUPPLY**

**Construction of Talaghan and Mamloo dams:**
A yield of 240 million cubic meters of water from these dams have been allocated to city of Tehran. These two dams are under construction and will become operational within next 3 years.

**Currently increasing water transfer from Lar dam:**
The Lar Dam, water conveyance line and related tunnel together comprise one of main sources of water for greater Tehran. Currently about 70 to 100 million cubic meters are being supplied from this source. It is anticipated that an additional 60 more million cubic meters of new water will be able to be transferred if all plans considered for this project are executed.

**Constructing new conveyance lines and treatment plants**
The fifth, sixth and seventh water treatment plants of Tehran, with a capacity of 20 cubic meters of water treatment per second and 65 Km of conveyance lines from Karaj and Mamloo to Tehran, will be constructed over a five year period.

Currently, the first phase of the fifth water treatment plant is underway, but whether it will take raw water from Lar dam is yet to be seen. The sixth water treatment plant, which will take water from...
Karaj dam, and the seventh water treatment plant, which will take water from Mamloo dam, are also yet to be executed.

Figure 7: Chart of predicted water supply in 2021

![Water Supply Charts of Tehran - 2021](image)

**Consumption management**

The 180 million cubic meters of the total volume of extra water needed for year 2021 has to be provided via activities related to consumption management. Some of these activities include recording and analyzing consumption patterns, public relations activities to change public opinions about construction, changes to the fundamentals of national construction regulations, and assisting in the compilation and approval of standards for equipment used in the distribution and consumption of water.

Further, in considering the utilization of water consumption reduction devices, the following actions should be undertaken:

- separate use of high and low quality water;
- establishment of public education programs and research about social opinions;
- active participation in the production and distribution of radio and television programs about water conservation;
- establish active relations with the Ministry of Education and develop primary school education about water management;
- develop relations with NGO’s active in water-related issues;
- stage water conservation exhibitions;
- establish water resource education centers;
- teach water conservation techniques to high school and college students;
- undertake local education: establish small groups to promote water conservation culture and hold face-to-face meetings with stakeholder groups such as housewives;
- improve water pressure zones in urban water distribution networks;
conduct preventive maintenance and promote modern maintenance methods and work;
- conduct various studies and projects about water that is unaccounted for;
- install modern and precise water measuring equipment.

**SOME EXPERIENCES RELATED TO TEHRAN’S 2001 WATER CRISIS**

After three consecutive years of drought, in 2001 Tehran faced a 29 percent reduction in water resources, whereby 270 Million m$^3$ was reduced from 91 m$^3$/capita in a normal year (with deduction of UFW) to 64 m$^3$/capita in 2001. The city was in an state of crisis, during which time several actions were taken and solutions utilized:
- a crisis control committee was established;
- a map room was organized;
- an information room was established;
- cooperation from various stakeholder organizations was sought: the office of the governor-general, ministry of energy, municipality of Tehran, etc;
- meetings were organized and held with employees of the Tehran Province Water and Wastewater Company and other affiliated companies to define and establish crisis control and water resource management objectives;
- weekly progress meetings helped monitor all activities related to crisis control, attended by senior managers and project directors.

In order to compensate for a shortage of 270 million cubic meters of water, it was decided 50 percent of this volume should be obtained from ground water via excavation of new deep wells, and the remaining 50 percent via consumption management. About 200 new deep wells were therefore excavated, causing enormous problems.

Further, many different alternatives and solutions related to consumption management were experienced, such as:
- reduction of water pressure in the distribution network;
- installation of water consumption reducing devices;
- shut-down of water in the network during night time;
- disconnection of the water service of subscribers who don’t adhere to prescribed consumption;
- disconnection of water services based an pre-announced schedule in some limited areas;
- periodical shut-down of water services during the day in some parts of the city for six months.

The periodical shut-down of water services had some positive effects in reducing consumption, as this schedule was executed for six days a week from 9 am to 9 pm, excluding Friday (considered the ‘weekend’ in Iran). Gradually, in some parts of town located at higher altitudes, the length of shut-down time of water service was reduced to ten hours a day. One of the main problems in relation to this process was air ventilation in the network, for which finding a solution was extremely cumbersome. In general, there was widespread public dissatisfaction with water shut-downs, with citizen complaints and objections made via newspaper, calls to television and radio stations, etc. It is acknowledged that such periodical closure of water services is a very dangerous alternative, and should only be considered or implemented as a last resort.

To counter these negative impacts of water shut-downs, several other solutions were also used, including:
- increased water supply capacities;
- improved quality control systems;
- improved water conveyance and pumping capabilities;
- reconstruction, leakage control and alteration of sensitive valves in the distribution network;
- re-checking of water volumes entering and exiting from water reservoirs;
- establishment of water network zones;
- re-construction of water service lines and extensions;
- separation of water used for plants/greenery;
- disconnection of illegal connections;
- reduction of UFW (unaccounted for water);
- changes to water meters and use of new pipes;
- expediting and shortening the time period of responding to accidents;
- installation of consumption reduction devices;
- changes to national construction regulations;
- cooperation in writing technical standards for various water valves;
- changes to water tariffs and fines for those who avoid payment;
- increased attention to consumption patterns and utilization of long-term consumption management techniques.

Figures 8 (a) and 8 (b): workers in wastewater plant
SUGGESTIONS/ PROPOSALS FOR WATER MANAGEMENT IN MEGACITIES

Further to these ‘lessons learnt’ from the water crisis situation in Tehran, it is useful to consider general suggestions and points of improvement to better manage water in mega cities, such as, for example:

- prioritising water consumption reduction management, including planning and investment;
- creating and developing water supply installations, related to distribution and control of water quality;
- defining consumption patterns and executing consumption management strategies;
- promoting the improvement of operational water resource technologies, and utilizing modern quality control technologies and quantity control devices;
- executing public relations and educational programs;
- collecting and treating urban wastewater by undertaking specific projects in this regard;
- securing water resource management networks against natural disasters;
- implementing and using a Graphical Information System;
- creating the modern urban water telemetry and tele-control system;
- increasing coordination amongst different types of organizations responsible for urban challenges that confront mega cities, such as water resource management.

CONCLUSION

Focusing on water equally entails focusing generally on issues related to development and culture. In times of water shortages and increases in water demand, this in turn can implicate hostilities as citizens and organizations fight over scarce and finite resources. Public determination and the right planning can act as a catalyst for more effective water management, improved urban development and implementation of effective practices for the vitality, sustainability and social welfare of mega cities. By examining case studies, sharing experiences and following best practice examples, organizations around the world can benefit from those assessments made by their peers. In the case of Tehran’s water crisis and related experience, it is hoped that this example will help the axis of cooperation among cities and countries so as to avoid duplication of negative impacts and facilitate replication of positive solutions to managing water in a mega cities.