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Algiers carrying capacity with respect to per capita domestic water use

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ABSTRACT

Water is a vital resource for humankind existence, and all ancient civilizations grew near rivers and waterholes. Wellbeing and health concerns are closely linked to the level of water consumption. That is why household water use constitutes the most important component of water supply and planning system. Rational management of this valuable resource is all the more imperative in countries facing water scarcity. In the mid nineties water shortages were frequent in Algiers and the situation worsened with cyclical droughts and population growth. Algerian government has launched major infrastructure projects consisting of dams and desalination plants to expand the water supply system. In this paper we will focus on Algiers carrying capacity with respect to household water use. We will first give a description of the current water supply system. Algiers water carrying capacity assessment is made considering internationally admitted levels of household consumption and taking into account water inputs that can significantly vary according to dry and wet years. The specific results can be used at a strategic level to lay the foundations of an urban sustainable policy.

1. Introduction

The rampant growth of the world population exerts pressure on available natural resources, and can lead to resources depletion and harmful effects on the environment. In the past, several scholars have warned on the inadequacy between resources supply and population growth. Despite his pessimistic view, Malthus (1798) was among the precursors that have raised the necessity to control the population growth. Malthus emphasized that the exponential population growth would lead to food shortage given the assumption of a linear growth in food production. Verhulst (1838) put Malthus idea into a mathematical equation well known as the logistic equation describing human population growth. Ehrlich (1968), under the explosive title "population bomb", outlined the earth finite capacity to sustain human civilization (a revisited paper was published in 2009). Meadows et al. (1972), in their seminal report to the Club of Rome, investigate five major issues of global concern that are: rapid population growth, malnutrition and starvation, economic growth and its corollaries, depletion of non-renewable resources and environmental damages. They concluded that if the overall situation remains unchanged, the limits to growth on earth will be reached over the next hundred years. Barnosky et al. (2012) once again sounded the alarm. They highlight the risk of global ecosystem brutal shift, brought about by human activities, and could cause dramatic consequences for mankind.

There is unanimous agreement that humanity must live within its supply capacity and assimilation of discharges. Carrying capacity is a concept that deals with this issue to ensure a sustainable development of humankind (Arrow et al., 1995; Cohen, 1995). This concept stems from biology: "the carrying capacity of a given ecosystem is the total number of organisms in a given species for which there are sufficient resources, so that they survive and reproduce". For human beings, Rees (1992) defined carrying capacity as: "the maximum rate of resource consumption and waste discharge that can be sustained indefinitely in a given region without progressively impairing the functional integrity and productivity of relevant ecosystems".

The majority of the world population lives now in cities, and this trend will continue in the future. Unbridled growth of cities worldwide poses a serious threat to global environment. Several authors have attempted to adapt the concept of carrying capacity to the urban context. For Godschalk and Parker (1975), the carrying capacity is the ability of the natural and built environment to withstand the demands of the various uses. According to Schneider, Godschalk, and Axler (1978), the carrying capacity is the ability of a natural and artificial system to absorb the population growth

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Table 1
Water requirements and levels of health concern (WHO, 2011).

Service level	Distance/time	Per capita volumes of water	Level of health concern
No access	More than 1 km/more than 30 min round-trip	Very low: 5 l per capita per day	Very high Hygiene practice compromised Basic consumption may be compromised
Basic access	Within 1 km/within 30 min round-trip	Approximately 20 l per capita per day on average	High Hygiene may be compromised Laundry may occur off-plot
Intermediate access	Water provided on-plot through at least one tap (yard level)	Approximately 50 l per capita per day on average	Low Hygiene should not be compromised Laundry likely to occur on-plot
Optimal access	Supply of water through multiple taps within the house	100–200 l per capita per day on average	Very low Hygiene should not be compromised Laundry likely to occur on-plot

and physical development without degradations and damages. Oh, Jeong, Lee, Lee, and Choi (2005) defined the carrying capacity as the level of human activities, population growth, land use, physical development that the urban environment could support without causing serious damages and irreversible degradations. Berezowska (2007) emphasized the importance of thresholds management to master urban development. Yang, Su, Zhang, Zhang, and Hu (2010) outlined several limiting factors of urban ecological carrying capacity for the urban ecosystem development.

Water is a vital resource for mankind and therefore a critical issue in urban carrying capacity. With a significant population growth and in conjunction with pessimistic climate change scenarios (Kundzewicz et al., 2008), pressure on water has increased, especially in water stressed countries, inducing severe water shortages. The United Nations Organization FAO (2007) states that by 2025, “1800 million people will be living in countries or regions with absolute water scarcity and two-thirds of the world population could be under conditions of water stress”. The situation will be exacerbated by the rapid growth of urban areas that exerts heavy pressure on local water resources.

Water resources carrying capacity assessment is a major issue in urban planning. Integrated urban water management is of critical importance for sustainable development and preservation of water resources (Gober, Wentz, Lant, Tschudi, & Kirkwood, 2011; Hellström, Jeppsson, & Kärrman, 2000; McDonald et al., 2011). Many studies have concerned water resources carrying capacity in Asian big cities (Joardar, 1998; Mei, Liuyuan, Duhuan, & Yangxiaoyan, 2010; Min, Zhenghe, Limin, Yunhai, & Xiufeng, 2011; Song, Kong, & Zhan, 2011; Xiufeng et al., 2011). In the MENA (Middle East North Africa) region, the water issue is also critical. Water scarcity was the source of conflicts between nations (Cooley, 1984; Falkenmark, 1989; Gleick, 1993; Kliot, 1993). Talks on water sharing were held even though states were in legal state of war. This sensitive issue must be handled rationally and serenely, in the long run, to shift from confrontation to cooperation (Falkenmark, 1990; Falkenmark & Folke, 2002; Sivakumar, 2011). In December 2010 the United Nations General Assembly declared 2013 as the United Nations International Year of Water Cooperation.

Algeria that belongs to the MENA region is the largest country in Africa. It is generally classified as semi-arid country affected by water stress. But this description hides a disparity between regions. The Sahara that covers 87% of the territory is an arid desert with scarce rainfall while the extreme northern part of the country is characterized by a Mediterranean climate. Water resources are unevenly distributed between regions. 90% of surface waters are located in the north of the country (UNEP, 2011) where the majority of the population is concentrated. Algeria is among the countries with low water resources. This situation is exacerbated by cyclical droughts. According to the FAO (2013), Algeria has a natural water supply below 500 m^3 per capita per year, and is therefore considered in absolute scarcity.

Algiers, the political and economic capital of Algeria, is one of the major coastal cities around the Mediterranean Sea. It also concentrates urban facilities of national importance (hospitals, universities, sports arenas, etc.) and many economic activities. Algiers population has significantly increased since independence inducing pressure on water resources. In the mid-nineties water shortages were a prevailing phenomenon and the situation worsened with cyclical droughts. To address this situation, the government has launched major water infrastructure projects. Since 2002, new dams and desalination plants have been built. The current water supply system has been operational since 2011, and has not yet been confronted with drought.

In this paper we will focus on Algiers carrying capacity with respect to household water use. We will first give a description of the current water supply system. Algiers water carrying capacity assessment is made considering internationally admitted levels of household consumption, on the one hand; and taking into account several water supply related to drought conditions, water-use structure and network efficiency, on the other hand. This paper is organized as follows. We present in Section 2 human water requirements indices. In Section 3, we describe Algiers water supply system. Water resources carrying capacity assessment is given in Section 4. Section 5 is devoted to discussion. Conclusions are given in Section 6.

2. Human water requirements indices

Several indices have been developed to assess water availability or unavailability (Brown & Matlock, 2011; Rijsberman, 2006). Water indices, commonly called water scarcity indices or water stress indices, are expressed in terms of per capita water availability. One of the most widely used indices is the Falkenmark water stress indicator (Falkenmark, Lundquist, & Widstrand, 1989) that assesses renewable water resources per capita per year often on a national scale. A country is considered in “water stress” when annual water supply is below 1700 m^3 per capita per year. If the supply falls below 1000 m^3 per capita per year, the region faces water scarcity. This easy to use indicator provides an overview of natural freshwater resources availability in a given country. Nevertheless, the use of this indicator has its limitations (White, 2012). In large countries, regional disparities are hidden. There can be water shortage in one region and flooding in another, at the same time. Moreover, this indicator does not account for non-conventional water sources such as desalination (Bremere, Kennedy, Stikker, & Schippers, 2001; Elimelech & Phillip, 2011; Schiffler, 2004) and water reuse.

In their works, Shiklomanov (1993, 1998, 2000) and Shiklomanov and Rodda (2003) assessed water withdrawals by region and sector taking into account water use for domestic, industrial and agricultural sectors for more refined water consumption estimation. Urban area water resources carrying