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Algiers water issue: Key indicators for a diagnosis of water resources carrying capacity

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Abstract. In Algeria and especially in Algiers the capital city, ensuring inhabitants water requirements remains a critical issue despite huge investments made by the government to secure water supply over the past years. Indeed, in the face of erratic climate conditions with recurrent drought episodes and constantly increasing water demand, due to population growth and economic activity rise, the water supply system is subject to various problems of environmental, economic, technical and managerial nature. This could ultimately affect the water supply of Algiers city. A rigorous and effective management of water resources requires analysis of elements that affect in the long run water resources carrying capacity (WRCC). This latter can be defined as the level of human activity that can be withstood by the available water resources without major degradation of aquatic environments while maintaining an adequate standard of living for the population. Water resources carrying capacity depends mainly onto two major components that are water supply capacity and inhabitants' global water demand. This study aims at proposing key indicators and related thresholds for analysing Algiers water carrying capacity in order to provide a diagnosis tool for policy makers to lay down the foundations of a sustainable water strategy in Algiers city.

Keywords: Algiers water supply, Key indicators, Water system diagnosis, Carrying Capacity.

1. Introduction

Access to drinking water is a major concern as the survival of the human being depends entirely on it. Thus, the issue of securing water supply and sustainable management of this resource must be included in the priorities of any development strategy. This is all the more important in a country like Algeria, which have an average water availability less than 500 m³ per inhabitant per year well below the scarcity threshold set at 1000 m³ per inhabitant per year (Falkenmark, 1989), is clearly in water stress situation. Even worse, the situation will get more dramatic due to global warming, which could lead to an increased recurrence of drought episodes.

Among Algeria cities, Algiers, the political and economic capital, suffered from severe water scarcity due to several factors. The most important ones are recurrent droughts conditions and high pressure on resources, due to a fast population growth. In order to meet the growing demand for water, the Algerian authorities have favoured a policy of supply, investing heavily in new infrastructures. Transfer systems were implemented bringing water from dams located hundreds of kilometres from the capital. At the same time, desalination of seawater has been implemented to address the problem of the shortfall in natural water supply, in this region subjected to recurrent episodes of drought. It should be noted that this process is quite costly in terms of energy, and the long-term impact on aquatic ecosystems is unclear.

As a result of the efforts made, Algiers' citizens benefit now from water availability 24 hours a day. However, this relative comfort in terms of water supply remains questionable in many respects, because: groundwater, due to exploitation beyond its potential, is threatened

with exhaustion and subject, as they are coastal, to the phenomenon of marine intrusion; about half the volume of water allocated to the capital comes from superficial resources located in neighboring departments, which are forced to concede part of their water resources to the detriment of their own development (Chikhr Saïdi, 1997); Recurrent droughts greatly affect the contribution of these surface resources, while desalination of seawater cannot be a safe and sustainable solution as regards economical and environmental aspects (Cotruvo, 2011).

In view of these concerns, the objective of water policy is, on the one hand, to guarantee the sustainability of the resource and, on the other hand, to satisfy the demands of growing populations and different socio-economic activities, and allocating water amounts among different competitive uses taking into account local constraints (Kettab, 2001).

A rigorous and effective management of water resources requires analysis of elements that affect in the long run water resources carrying capacity (WRCC) (Shi & Qu, 1992; Zhongmin, 1999; Li, Guo, & Chen, 2000; Liu & Chen, 2007; Feng, Zhang, & Luo, 2008; Li, Wei, & Lu, 2010). This latter can be defined as the level of human activity that can be withstood by the available water resources without major degradation of aquatic environments while maintaining an adequate standard of living for the population (Naimi Ait-Aoudia & Berezowska-Azzag, 2016).

This study aims at proposing key indicators and related thresholds for analyzing Algiers water carrying capacity in order to provide a diagnosis tool for policy makers to lay down the foundations of a sustainable water strategy in Algiers city. This paper is organized as follows. Section 2 is devoted to Water carrying capacity key indicators. Thresholds of these indicators are detailed in section 3. The diagnosis of Algiers household water resources carrying capacity is given in section 4. Section 5 concludes the paper.

2. Water carrying capacity key indicators

The study of the urban carrying capacity relative to water resources is based on two key concepts: supply capacity and the demand side. These two concepts will be fleshed out in a set of indicators.

2.1 Supply water indicators

To study the carrying capacity at the urban level, Oh et al. (2005) define four components that are: environmental capacity, infrastructure capacity, perceptual capacity and institutional capacity. These components focus on the description of supply capacity. In the area of water, the environmental component represents amounts of water provided by the annual average flow of rivers and the annual renewal of groundwater resources; The infrastructure component represents the infrastructure for water intake and transport, as well as facilities for the production of unconventional resources, namely desalination of seawater and waste water recycling; Integrated water resource management has several objectives as increasing water availability by preventing resources from depletion and by promoting reuse, limiting water withdrawals to sustainable levels by maximizing water use efficiency, minimizing wastewater production and optimizing the distribution of water between competing users (OCDE, 1998); Perceptual carrying capacity includes human attitudes and behaviors.

In this study we will focus on indicators related to the environmental, infrastructure and management components. The objectives of these indicators are diverse and varied. Indicators for the environmental component aim at describing the factors affecting the overall availability of water resources. Infrastructure component indicators aim at assessing the actual

capacity and effectiveness of infrastructure. The indicators of the management component are intended to characterize the effectiveness of regulation, institutions, and water services.

Finally, 10 indicators were chosen to describe the supply capacity: 'exploitation rate of groundwater resources', 'surface water mobilization rate', 'desalination capacity', 'loss rate in adduction network', 'loss rate in the distribution network', 'Water reuse rate' and 'water structure', Quality of administration and water service (ordinal scale), Quality of regulation (ordinal scale), Law authority (ordinal scale)

2.2 Individual water consumption indicators

The domestic consumption component focuses on measures to reduce domestic demand for drinking water in order to reduce water withdrawals. The three axes that are favored to get people saving water, and which we propose to describe through indicators, are pricing, promotion of water-saving household equipment and rainwater harvesting.

Key indicators for individual water consumption are, 'water expenditure in household budget', 'percentage of households with water-saving devices' and 'percentage of homes using rainwater'.

3. Indicators thresholds

3.1 Measurement scale

The relevance of an indicator depends on its ability to depict the phenomenon being measured. In order for an indicator to be appreciable, it is important to compare it to a benchmark value on an ordinal scale (which makes possible to establish a hierarchy with respect to the measured indicator, e.g. good, fair, poor) or on a cardinal scale that allows quantification of the measurement with respect to a target value (Mayster, 1997; Spangenberg, Pfahl, & Deller, 2002) (Desthieux, 2005). This latter can be a standard proposed by international, national or even local bodies, resulting from a benchmark, or relating to the evaluation of the state of the phenomenon at different times (Von Stokar, Frick, Schultz, Keiner, Rey, & Mettan, 2001).

The three institutional indicators: Quality Index of Administration and Water Service, Quality of Regulation, Authority of Law, are qualitative indicators measured on an ordinal scale (good, fair, poor),

All the other selected indicators are cardinal, so their assessment is quantifiable and is done in relation to a benchmark value. All these quantitative indicators are expressed as a percentage and could take values between 0% and 100% called extreme thresholds, which after standardization take respectively the values 0 and 100. The significant thresholds in the range 0-100 represent benchmarks defining intervals of values that the indicator: could or should take (recommended) represented by the green color, could take with reserve (reserve) represented by the orange color, avoid taking (prohibited) represented by red color, and finally could take but its impact would be insignificant compared to the system studied (not significant), represented by the gray color. We adopted this color code, inspired by nutrition labeling in use in some countries for its obvious and easy apprehension by decision-makers.

3.2 Indicators significant thresholds

Significant thresholds for indicators as regards exploitation of superficial natural resources refer to United Nations standards (in the comprehensive inventory of world resources (E/CN.17/1997/9) which set a water withdrawal rate not exceeding 40% for a sustainable use

of the resources respecting the minimum needs of the ecosystems. Beyond 70% the situation is called critical (PNUE, 2006) and reveals an intense shortage of water.

With regard to underground resources, water withdrawals should be made only from renewable water volume estimated 300 million cubic meter in order to avoid ground water lowering. In a study referred to as PAC on the coastal area of Algiers, a rate of withdrawals on the renewable water above 80 % is allowed, without exceeding the maximum threshold of 100% (Larid, 2003). For this indicator, the threshold of 100% means exploiting totally the renewed volume of water. Exceeding 100% means that the water table level will drop until a state of dangerous depletion.

Due to the absence of national standards about the loss rate in adduction network and the loss rate in the distribution network, we have referred to performances in developing and OECD countries. Hence, the maximum threshold of lost in the distribution network is fixed at 10%, a performance achieved in several countries of the OECD (OCED, 1998). With regard to losses in adduction network, whose pipes are easier to fix, freed from the constraints of urbanization, a maximum threshold of 5% is adopted.

As well, a rate of 1% for the indicator 'water expenditure in household budget, constitutes the minimum threshold observed in several countries and local communities. Proper water pricing is necessary to cover the actual costs of water service but also to encourage the consumer to adopt a more sparing use of this scarce resource. The OECD estimates that it is possible to go up to a rate of 3%, if necessary. It is also worth noting that a rate of 10% or more can be a threat to the standard of living of low-income households.

Indicators related to wastewater reuse, rainwater recovery and the use of water-saving appliances reflect the success of the policy of promoting the rational use of water resources. The goal is to reuse 100% of the wastewater and to get 100% of the households installing rainwater recovery and water-saving appliances. However, below the threshold of 5%, the impact on water demand will not be significant.

As regards desalination of seawater, setting thresholds is not evident, since it is an expensive process for the production of drinking water (Thivet & Fernandez, 2012), and the knowledge surrounding this technique is still insufficient to assert that it is safe for the marine aquatic environment. In some countries the supply is only made through desalination but the use of this process is still subject to reservation. Therefore the whole field of value relating to this indicator will be set to reserve.

The same applies to the amount of water allocated to domestic households, which depends on socio-economic conditions, level of development, nature of the predominant activities in the region and also climatic hazard which, in some cases forces to privilege domestic consumption. The current amount of domestic use is about 51% but could be increased if measures are taken to promote more efficient use of water by other activities such as the generalization of economical irrigation techniques, wastewater reuse by industrial and agricultural activities.

Table 1. Indicators and related thresholds.

Indicator	Significant thresholds		
exploitation rate of renewable groundwater resource	≤80% Recommended	> 80% et <100% with reserve	>100% To avoid
Surface water mobilization rate	≤ 40% Recommended	> 40% et <70% with reserve	>70% To avoid
Desalination capacity		with reserve	
loss rate in adduction network (%)	≤ 5% with reserve	> 5% To avoid	
loss rate in the distribution network	≤ 10% with reserve	> 10% To avoid	
Water reuse rate	≤ 5% Not significant	> 5% Recommended	
Domestic water structure	<50% with reserve	≥50% Recommended	
Quality of administration and water service	Poor	Fair	Good
Quality of regulation	Poor	Fair	Good
Law authority	Poor	Fair	Good
water expenditure in household budget	≥ 1% et ≤3% Recommended	<1%, >3% et ≤10% with reserve	>10% to avoid
percentage of households with water-saving devices	< 5% Not significant	≥ 5% Recommended	
percentage of homes using rainwater	< 5% Not significant	≥ 5% Recommended	

4. Algiers household water resources carrying capacity diagnosis

For an easy reading of the indicators values, we use a stacked bar chart. Every stacked bar, corresponding to one indicator, has colors according to defined significant thresholds. The diagram become, hence, a matrix for reading indicators values. Figure 1 shows color code for the indicators and the measured value of each indicator relative to the situation of Algiers.

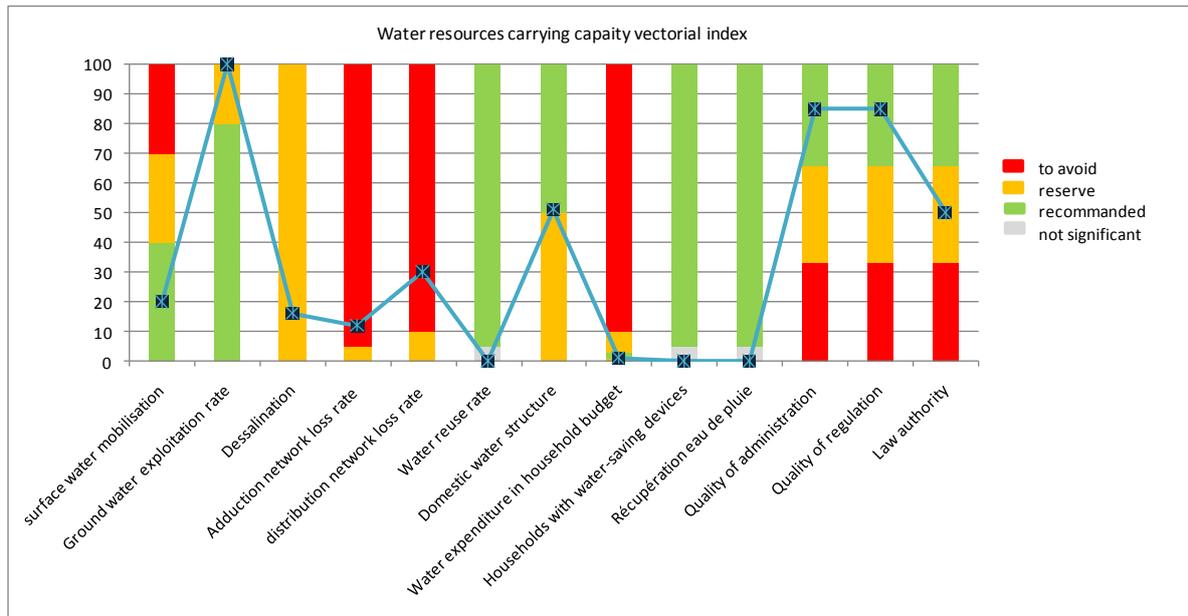


Figure 1. Vectorial stacked bar chart for the diagnosis of water policy.

The measurement of key indicators provides a global view of the main determinants of the carrying capacity of water resources in the capital city.

4.1 In terms of supply capacity

From a previous study, we know that the infrastructure in place allows us to mobilize about 20% of the water collected in the watersheds, that groundwater table is overexploited and that the desalination water constitutes 17% of the total amount of water allocated to the capital (Naimi-Ait-Aoudia & Berezowska-Azzag, 2014). In addition, the loss rates are around 12% in the supply networks (Benblidia M. , 2011), and 30% in distribution networks according to SEEAL the company in charge of water management in Algiers. Thus, apart from the exploitation of surface resources, which has a positive value and reflects the region's perspective in improving water supply capacity through the construction of new dams, the rest of the indicators of this category are in orange and red, which implies the need to take tangible measures to improve the availability of water and preserve the underground resources.

4.2 In terms of management capacity

The Algerian government seems to have succeeded in setting out a water management policy. The legislation adopted is clear (Benblidia & Thivet, 2010), covering all aspects related to the water sector, namely exploitation and concession of resources, pricing, combating water pollution and social policy. In addition, under a recent law, the concept of sustainability has become a guideline for water policy. The shift from sector management policy to sustainable and integrated resource management was achieved through the establishment of river basin agencies (Benblidia & Thivet, 2010; Mozas & Ghosn, 2013) which take, among other things, responsibility to raise domestic, industrial and agricultural users awareness for rational use and protection of resources. It should be noted that the status of basin agencies provides for the participation of users in the preparation of master plans (BAfD/OCDE, 2007), a first in the annals of management in Algeria. However, river basin agencies face difficulties in becoming a mediator in integrated water resources management, due to duplication of work with central government departments and lack of financial resources. Despite this, the quality of the administration appears to be generally satisfactory.

Mozas & Ghosn (2013) underline a better distribution of competences between the different agencies in the water sector compared to the past. Ultimately, it seems clear that the public authorities have the necessary institutional means to lead the management of a sensitive sector in the country, even if there some flouting in law enforcement.

4.3 In terms of demand regulation

While the Algerian government has made considerable efforts to increase supply capacity, efforts to make efficient use of this resource have been delayed or not undertaken at all.

From all the actions aiming at reducing water demand described by the key indicators selected, only that relating to pricing was implemented. Prices have been revised upwards in conjunction with gradual pricing in terms of volume consumption.

The incentive for water savings should be implemented through awareness of consumer about the importance of preserving this valuable resource and the advantages of adopting behaviors aimed at that goal both on environmental and economic aspects. Furthermore, the gain that might bring the reuse of water was unfortunately ignored for a long time by public authorities. But recently, the intention to exploit this water potential, especially in irrigation, was clearly stated in the preparation of the Metropolitan Land Use Plan.

5. Conclusion

The urban management aims at matching the objectives of urban development with urban ecosystem capacity to provide the necessary resources for human development. That is why the management of water demand as much as on supply is of critical importance especially in a country with limited fresh water resources like Algeria. In this respect, water carrying capacity assessment provides, policy makers, elements of appreciation to lay down the foundations of a sustainable urban development policy. Based on the characterisation of both supply and demand water components, we have proposed key indicators and related thresholds for analysing Algiers water carrying capacity in order to provide a diagnosis tool and a dialogue interface for policy makers to negotiate possibilities for improving the water service while maintaining water resource sustainability.

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