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THE WASH VULNERABILITY OF ALGERIA'S POPULATION AND ANALYSIS OF CONTRIBUTING FACTORS

CITLIVOSŤ OBYVATEĽSTVA ALŽÍRSKEJ ĽUDOVO-DEMOKRATICKEJ REPUBLIKY Z HĽADISKA HYGIENY A PRÍSTUPU K PITNEJ VODE A SANITAČNÝM TECHNOLÓGIAM

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ABSTRACT:

Data on the Algerian population's access to improved sources of drinking water and to improved sanitation facilities and social/economic vulnerability of the population were extracted from the World Bank databases and Index Mundi. The WASH vulnerability criterion (WVC) of Algeria was calculated using this data, enabling the calculation of the social and economic vulnerability criteria for the population. The WVC values ranged from 0.062 to 0.117, with values that were higher in rural areas of the country. The Pearson correlation coefficients were equal to 0.4866 for the correlation between WVC and social vulnerability, and to -0.5288 for the correlation between WVC and economic vulnerability. Both correlations were not statistically significant, at 5 % level of significance (p-values = 0.1841 and 0.1420, respectively). The WASH vulnerability of the Algerian population is therefore not strongly dependent on its social or economic vulnerability. Recovery of water provision/production costs from consumers must be improved to increase the financial sustainability of the country's water management organisations and to facilitate upkeep of its water/sanitation infrastructures. Capacity to implement the necessary project and to effectively manage the expenditure of the funds allocated has to be improved. Installation of decentralised wastewater treatment solutions, with a focus on algal biotechnology, should be encouraged as a possible solution to the wastewater treatment challenges faced by Algeria. Provision of sanitation in rural areas must be given priority status in government spending and involvement of multiple stakeholders in water and sanitation management operations must be strengthened through existing disaster management approaches.

KEYWORDS: *economic vulnerability; WASH vulnerability; water and sanitation; Algeria*

INTRODUCTION

Algeria is the largest country on the African continent, with a total geographical area of 2 382 000 square kilometres [1]. It has reached a medium level of human development, with a Human Development Index of 0.736 in 2015 [2]. Northern Algeria has a Mediterranean climate, and this shifts into a transient climatic zone over the central plateau, and then into a dry and hot climate over the Sahara Desert in the south [3,4]. The presence of various climatic regions across Algeria leads to a highly fluctuating geographical distribution of rainfall, with records showing that each region receives its highest precipitation at different times of the year [5]. Rainfall volumes have decreased over recent years [6] and recurring droughts have been observed over the last 30 years [7].

Droughts and decreased rainfall have likely had profound and negative impacts on the flow regimes of Algerian watercourses [7].

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The majority of the drinking water in the country is extracted from surface water and groundwater [8]. Rainfall patterns and persistent droughts can, therefore, have a negative influence on access to improved drinking water and could also compromise the water, sanitation and hygiene (WASH) situation faced by the Algerian population. The Algerian water authorities and governments have long faced challenges in the water provision for the region of the Central Plateau and the Sahara [9]. This can be documented by the fact that these two regions together occupy up to 93 % of the total land area of Algeria, but only receive 10% of the total volume of extracted fresh water [9]. The country's reticulation infrastructure is often plagued by leaks, leading to a loss of 45 - 50 % of the available annual volumes of potable water [10,11]. Other challenges pertaining to the water supply include budget deficits in water management institutions and a lack of efficient implementation of institutional/ legislative mechanisms in the water sector [12].

Budgetary challenges and leaks in the reticulation infrastructure have been among the factors contributing to the stressed potable water supply available to the Algerian population. This stress is indicated by the steadily decreasing availability of water per capita over the last 50 to 60 years. The theoretical water supply per capita was estimated at 1500 m^3/person/year in 1962 [9]. This volume decreased to 720 m^3/person/year in 1990; to 680 m^3/person/year in 1995, and is now expected to drop to 430 m^3/capita/year by 2020 [9]. This is further confirmed by data from the World Bank which indicate that the water availability per capita has been fluctuating around 400 m^3/capita/year, well below the World Bank water stress threshold of 1000 m^3/capita/year [8].

Increased urbanisation and internal displacement have been ongoing in Algeria since at least the 1980s and have resulted in the development of informal urban settlements [13]. The rate of urbanisation in such settlements is often higher than the rate of sanitation service delivery by (local) government, resulting in inadequate access of the population to improved sanitation. Infrastructure, such as wastewater treatment plants, have been shown to suffer breakdowns and this has resulted in inadequate wastewater treatment in many parts of Algeria [10,11,13]. Septic tanks are a common source of groundwater contamination in the North-eastern region of the Algerian Sahara [14]. Health challenges related to sanitation provision and hygiene have been reported since the adoption of the Millennium Development Goals (MDGs), e.g. an outbreak of bubonic plague occurred in a rural area in 2003 [15]. Leading causes of human mortality on the African continent include lower respiratory infections, as well as parasitic and diarrhoeal diseases [16]. The effects of these and other communicable diseases account for 21 % of the total disease-adjusted lost years (DALYs) and 24 % of lost DALYs in Algeria in 2012 (page 22 in reference [16]). Based on this information, the WASH vulnerability of the Algerian population requires ongoing attention.

Some measures to decrease the WASH vulnerability of the population have been successful in recent years. Firstly, 95 % of one-year-old children have been immunised against measles [17,18]. Vaccination rates against poliovirus, diphtheria, tetanus and pertussis in the same age group have increased from 89 % in 1990 to 95 % in 2014 [19]. Similarly, vaccination rates against hepatitis B have remained steady, at 95 % of all one-year-old children in Algeria over the same time period [19]. These and other mitigation measures contributed to the 45 % drop in the infant mortality rate and a 44.7 % decrease in the under-five-year mortality rate between 1990 and 2015 [16-18]. Algeria's achievements in tackling its WASH vulnerability have therefore been significant but still fall short of the MDG target of a 67 % drop for the 1990 - 2015 period [17,18]. Therefore Algeria and its population are likely to continue facing WASH challenges, requiring ongoing research into the WASH vulnerability of the Algerian population.

The Algerian National Institute of Public Health started a campaign to decrease the disease burden from waterborne diseases in 1987 which has contributed to lower numbers of cases reported throughout the country [20]. To achieve better management and further decrease the WASH-related vulnerability of its population, the Algerian government has also participated in international desalination projects to increase access to improved drinking water [21]. Water quality data is collected regularly around the country by state authorities such as the National Water Resource Agency (Agence Nationale des Resources Hydrauliques) [14]. However, microbial safety of drinking water remains a concern, as demonstrated by the following indicators, summarised by Achour and Chabbi

[22]: 16 to 18 % of all drinking water samples were positive for microbial indicators such as Escherichia coli and 9 % of all water treatment works did not produce potable water that met regulatory requirements in 2008 [22].

At the same time, the number of drinking water reservoirs which underwent regular inspections and were subjected to treatment decreased substantially between 1987 and 2008 [22]. Budgetary and technical capacity constraints provide the most likely explanations for decreased monitoring. Some principles of integrated water resource management and water reuse strategies have begun to be adopted across the country [23]. Increases in the population's access to improved sanitation, as defined by United Nations organisations, were apparent in Algeria by 2013 [24]. However, the text in the Introduction proves that challenges in water and sanitation provision remain. The aim of this current article is to examine the trends in the WASH vulnerability of the Algerian population and factors that control it. In this way, the authors seek to partially address a knowledge gap in the literature.

1. METHODOLOGY

The WASH vulnerability assessment was based on the percentage of the Algerian population with access to improved water resources and to improved sanitation facilities. Data were extracted from the respective World Bank databases for the period beginning in 1990 and ending in 2015 [25-30]. Using data from this time period, the progress that Algeria has made towards the achievement of the MDGs, or its lack thereof, may be assessed. The percentage of the Algerian population with access to improved water resources will be referred to as *AIWR* (%) in further text. Likewise, the percentage of the population with access to improved sanitation facilities will be represented by the abbreviation *AISF* (%). These terms will also be used for the dimensionless forms of both parameters. Data and calculation results that refer to the total population of Algeria will be represented by the subscript T in further text. Data and calculation results that refer to the urban population will be represented by the subscript U in further text. Finally, data and calculation results that refer to the rural population (represented by the subscript R in further text) segments.

One of the first tasks in the current study was to define a quantitative criterion to assess the WASH vulnerability of the Algerian population. Here, authors adopted an approach similar to that of Al-Kalbani et al. [31]. The WASH vulnerability criterion (*WVC*) should have the following properties. First, the WVC should not have negative values. Second, the criterion must take both *AIWR* (%) and/or *AISF* (%) into account, as each significantly influences the WASH vulnerability of the Algerian population. Third, *WVC* should increase in value if the WASH vulnerability of the Algerian population is increasing. Practically, this means that *WVC* should be inversely proportional to the values of both *AIWR* (%) and *AISF* (%). Based on these required properties, the WVC can be defined as shown in Eq. (1).

$$WVC = \log\left[100 * \frac{1}{0,5 * (AIWR + AISF)}\right] \qquad (1)$$

In Eq. (1), the *AIWR* and the *AISF* values were averaged in the particular year for the population of Algeria. This is the reason for the presence of the coefficient of 0.5 in the denominator on the right-hand side of Eq. (1). *WVC* values are reported as dimensionless, so *AIWR* and *AISF* were therefore converted to fractions from the percentages reported in the World Bank databases. This is the reason for the presence of the coefficient of 100 on the right-hand side of Eq. (1). As defined in Eq. (1), *WVC* (dimensionless) will have a minimum value of 0 if both *AIWR* and *AISF* equal 100% or 1.0, as the resulting logarithm will be equal to zero. Practically, this situation would only be encountered in Algeria if its entire population were to have access to improved water resources and improved sanitation facilities. The value then increases to 1.0 as *AIWR* and *AISF* values decrease towards 0 %. Practically, this situation would be encountered in Algeria if its entire population had access to neither improved water resources nor improved sanitation facilities.

WVC is inversely proportional to the values of *AIWR* and *AISF*. Therefore, as these decrease, the WASH vulnerability of the Algerian population increases, i.e. *WVC* increases. This definition of the WASH vulnerability criterion is analogous to the principle behind the definition of biological activity in medicinal chemistry, and this is why the logarithm scale is used in Eq. (1) and Eq. (2) [32]. For practical calculations, the *WVC* can be simplified as shown in Eq. (2).

$$WVC = \log \frac{200}{(AIWR + AISF)} \qquad (2)$$

All calculations of WVC were done for the total urban and rural populations of Algeria using OpenOffice Calc version 4.0 (The Apache Software Foundation 2015, www.apache.org) and/or Microsoft Excel 2010 (Microsoft Inc., Johannesburg, South Africa).

Several factors will control and/or be correlated with WVC; and will include social and economic variables. The choice of the actual indicators must take the following into account. First, calculation methods and indicators should be based on data available in the public domain. If the study is successful, then this would facilitate the use of the developed approach by a wider professional community. Second, source data must be relevant to the provision of improved water and sanitation in any given country. Based on these considerations, a literature search was conducted for mathematical indicators used to quantify economic and social vulnerability. Four studies were identified as possibly suitable for the purpose of this paper. Social vulnerability indicators have been defined by Flanagan et al. [33], André [34] and Lundgren and Jonsson [35]. Economic vulnerability indicators were calculated based on the approach of André [34] and Cariolle [36].

The approaches of Flanagan et al. [33] and Lundgren and Jonsson [35] required large numbers of independent variables for the calculation of social vulnerability indices. Public domain data availability for all the necessary independent variables might become an issue. The social vulnerability index of André [34] is based on the economic situation of the country, its population growth rate, the percentage of the population living in urban areas and on the level of human development. These variables are relevant to the provision of improved drinking water and access to improved sanitation. They are also available in the public domain. The approach of André [34] was therefore chosen to investigate the possible relationship between *WVC* and social vulnerability of the Algerian population. The economic vulnerability index of Cariolle [36] is based on weighting the number of people affected by disasters and the impact of these disasters on trade and agriculture [36]. It provides a valuable tool for disaster managers but is not directly relevant to the WASH vulnerability in Algeria. The economic vulnerability index of André [34] takes into account variables such as economic situations of the country, its population growth rate, the percentage of the population living in urban areas, and the Human Development Index. It was therefore chosen for use in further calculations.

Data for gross domestic product per capita (*GDP*; USD per capita) were obtained from databases of the World Bank [37]. Values of the fraction of the total population living in urban areas of the country (*FUP*; originally reported as percentages, but converted to fractions and reported as dimensionless) were obtained from the Index Mundi database [38]. The World Bank database was again used as the source for the population growth rate (*Cp*; dimensionless based on the same reasoning as *FUP*) [39]. Finally, the Human Development Index values (*HDI*; year$^{0.667}$) were obtained from the United Nations Development Programme database [2]. Given the parameter availability of values in individual datasets, values of economic vulnerability (*EV*) and social vulnerability (*SV*) were calculated for the following years: 1990, 1995, 2000, 2005 and 2010 - 2014 using Equations (3) and (4) [34].

$$EV = \frac{FUP + \log(GDP)}{Cp * HDI} \tag{3}$$

$$SV = \frac{FUP * Cp}{HDI * \log(GDP)} \tag{4}$$

Considering the above information, André's approach to vulnerability calculations yields the following units: *EV* (USD×year$^{1.5}$) and *SV* (year$^{1.5}$×USD^{-1}) [34]. All calculations were performed using the same software packages as outlined for the *WVC* calculations. In addition, the mutual relationship between WVC and *EV*/*SV*, or the lack thereof, were investigated by calculating the Pearson correlation coefficients and the respective p-values (Social Science Statistics, 2017 at http://www.socscistatistics.com/tests/pearson/ Default.aspx and http://www.socscistatistics.com/pvalues/pearsondistribution.aspx).

2. RESULTS AND DISCUSSION

Results of the *WVC* calculations for the total population of Algeria, along with all the source data from the World Bank, are shown in Table 1. Data in Table 1 show that WVC_T values ranged from 0.062 to 0.068 between 1990 and 2015. The minimum values were observed in the following years: 1999, 2001 and 2003; and the maximum value of WVC_T was observed in 2015. Between 1990 and 2015, $AIWR_T$ values decreased by 7.9 %, while $AISF_T$ values increased by 7.3 %. Thus, numerically, the decrease in access of the total population to improved water resources was compensated for by an increase in the overall access to improved sanitation facilities among the total Algerian population. As a result, the WVC_T remained relatively unchanged from 1990 until 2015 (see Table 1).

Challenges to water delivery and sanitation have been linked to the economic and social conditions prevalent in a particular country [40]. If this is the case in Algeria, then the WVC_T values should correlate with the *EV* and *SV* values. These values were calculated and are shown, along with the source data, in Table 2. The social vulnerability of the Algerian population was highest in 1990 when the *SV* value was equal to 6.87×10^{-3} $year^{1.5}\times USD^{-1}$. *SV* values then decreased, reaching a minimum of 3.63×10^{-3} $year^{1.5}\times USD^{-1}$ by 2005. Between 2005 and 2014, *SV* values increased and eventually levelled off at $4.94\text{-}5.00\times10^{-3}$ $year^{1.5}\times USD^{-1}$. The temporal trend of *SV* values was similar to the *WVC* trend for the 1990 - 2015 period. The values of *EV* increased from 119.85 $USD\times year^{1.5}$ in 1990 and to the maximum of 237.86 in 2005. After this, the economic vulnerability of the Algerian population decreased and fluctuated around 180 $USD\times year^{1.5}$ between 2012 and 2014. The *WVC* trend for the total Algerian population is different to that calculated for *EV*.

Calculations of the Pearson correlation coefficient revealed that WVC_T had a weak positive correlation with *SV* (Pearson correlation coefficient = 0.4866), but such correlation was not statistically significant, at 5% level of significance (p-value = 0.1841). There was a weak negative correlation between WVC_T and *EV* (Pearson correlation coefficient = -0.5288), but, again, this correlation was not statistically significant, also at 5% level of significance (p-value = 0.1420). The lack of significant correlation between WVC_T and *EV*/*SV* indicates that the combined effect of urbanisation, economic situations in Algeria and the level of human development was not the dominant factor governing the WASH vulnerability of the Algerian population. To get a deeper insight into its causes, the *WVC* calculations were re-run for both the urban and the rural segments of the Algerian population, separately. Results are shown in Tables 3 and 4.

In urban areas of Algeria, a minimum WVC_U value of 0.024 was recorded between 1990 and 1993. Since then, a steady increase in the WVC_U was observed, and its maximum value of 0.060 was reached by 2015 (see Table 3 for details). From a numerical point of view, this trend was most likely caused by a 13.1% decrease in $AIWR_U$ values (see Table 3). The opposite trend was observed in rural areas. The WVC_R value was constant at 0.117 between 1990 and 1993. There has been a steady decrease in the WASH vulnerability in the rural areas of Algeria between 1993 and 2015 (see Table 4). The minimum WVC_R value of 0.086 was observed in 2015. Overall, the rural population experienced a 26.5% decrease in its WVC_R value, mainly due to a 14.5% increase in the $AISF_R$ values (see Table 4). The WASH vulnerability in rural areas remained higher than in urban areas between 1990 and 2015. Data in Tables 1, 3 and 4 clearly indicate that the MDGs were not met in Algeria in terms of increasing access to improved drinking water resources or to improved sanitation facilities. This is supported by the WHO data [17,18] and contradicts predictions of Foeken et al. [24].

Volumes of available and renewable freshwater resources in Algeria (designated as freshwater resources in further text) remained constant at 1.125×10^{10} m^3 per annum between 1992 and 2014 [41]. This period is slightly different to that for which data for *AIWR* and *AISF* are available. However, these periods are close enough to allow for an evaluation of the potential reasons for the WVC calculation results. The percentage of freshwater resources extracted on an annual basis for various uses in Algeria increased from 40 % in 1992 to 74.89 % in 2012 - 2014 [42]. The freshwater resource percentage used by the Algerian industry declined from 15.11 % to 4.92 % between 1992 and 2014 [43], while respective values for agricultural uses remained relatively constant at 60 % in 1992 and 59.23 % in 2012 - 2014 [44]. The total volumes of freshwater resources extracted annually in Algeria thus grew from 4.5×10^{10} to 8.4×10^{10} m^3 per annum between 1992 and 2014.

The absolute volumes of freshwater resource extracted over the same time period for use in Algerian industry and agriculture also grew. However, the relative percentage of the total volumes extracted in a given year and used in industry decreased, while the relative proportion used in agriculture remained constant. As a result, the freshwater resource usage by the Algerian industry and agriculture does not provide an explanation for the calculated WVC trends. In other words, the AIWR values and WVC were not affected by industrial and agricultural water use. Increases in the extracted volumes of freshwater resources were most likely caused by the water demand of the Algerian population.

Table 1 **Source data and the *WVC* values for the total population of Algeria**

Year	$AIWR_T$ (%)	$AISR_T$ (%)	WVC_T (dimensionless)
1990	91.5	80.3	0.066
1991	91.6	80.5	0.065
1992	91.7	80.7	0.064
1993	91.8	80.9	0.064
1994	91.5	81.3	0.063
1995	91.2	81.7	0.063
1996	90.9	82.1	0.063
1997	90.5	82.5	0.063
1998	90.2	82.9	0.063
1999	89.9	83.3	0.062
2000	89.5	83.6	0.063
2001	89.2	84.0	0.062
2002	88.8	84.3	0.063
2003	88.5	84.7	0.062
2004	88.1	85.0	0.063
2005	87.7	85.3	0.063
2006	87.4	85.6	0.063
2007	87.0	85.8	0.063
2008	86.9	86.1	0.063
2009	86.2	86.4	0.064
2010	85.7	86.6	0.065
2011	85.3	86.8	0.065
2012	84.9	87.0	0.066
2013	84.5	87.2	0.066
2014	84.0	87.4	0.067
2015	83.6	87.6	0.068

Yet water availability per capita decreased from 413.893 m^3/capita/year in 1992 to 288.948 m^3/capita/year in 2014 [45]. Other factors that influence WVC must be at play. Limited studies on the pricing of water services in Algeria have reported that the National Water Company (ADE) incurs production costs of 1.25 EUR/m^3, but only 14.4 % is recovered from charges to water consumers, i.e. the Algerian population [46,47]. This places pressure on the budgets of water management authorities, which could, in turn, result in limited funds being available to maintain, expand and effectively manage water treatment facilities and supply infrastructures [47]. Survey results indicate that 87 % of respondents indicated that "they don't know the price of the potable water supplied by ADE and the local municipality" [47]. At the same time, 69 % of the consumers interviewed were open to paying more for water services if this would improve the quality of service [47]. Up to 30% of all water consumers opted to meet their drinking water demand by purchasing bottled water for drinking purposes at a price 1667 times higher than the potable water supplied by ADE and municipalities [47]. Water interruptions are common and leave some residents no option but to store drinking water for extended periods of time and potentially consuming stored water of inferior microbial quality [47]. This can increase WVC values by decreasing AIWR and AISF values. Increased spending is needed, as certain water sector spending has been neglected. For examples, 43 to 57 % of the total water and sanitation expenditure has been channelled into dam building, but the storage capacity in Algeria remains insufficient [11]. Only 16 to 20 % of finances in the water sector have been used on sanitation expenditure [11]. This item and water infrastructure spending must be increased urgently, especially in the rural areas, to decrease the *WVC* values faced by those populations.

The total municipal water generated in 2013 was 3.1×10^9 m^3 [48], and 6×10^8 m^3 of treated wastewater was made available for agriculture, compared to 9×10^7 m^3 in 1999 [49]. The use of wastewater for irrigation is governed by a legal framework that sets health and environmental safety requirements [49]. A policy developed by integrated water resources management aimed at improving all forms of irrigation is currently being exercised in Algeria. It ensures that water-saving irrigation techniques, such as trickle irrigation, are adopted in the country's agricultural practices. The volumes of water used in such techniques are small compared to the total volumes of extracted freshwater resources (see above). However, if treatment is targeted to specific areas where sanitation/wastewater treatment facilities are not available (e.g. rural Algeria), it could help decrease WASH vulnerability of the local population.

Coverage of the population by sewerage infrastructure is high, but it has been reported that only 20 % of the total volume of wastewater is treated [50]. This is the result of only 123 operational wastewater treatment plants across the entire territory of Algeria, as summarised by Achour and Chabbi [22]. As of 2016, there was a total of 145 wastewater treatment plants throughout the territory, with an additional 106 under construction [51]. The number of operational wastewater treatment plants, i.e. 123, only accounted for about 49% of the number actually needed. This could indicate that need to implement decentralised solutions for the treatment of domestic wastewater, greywater and related sanitation wastes [50]. At the same time, the use of existing wastewater treatment plants should be improved. This could be accomplished through strategies such as sewage sludge reuse, e.g. in agricultural applications.

Data in Tables 3 and 4 indicate that the WASH vulnerability of the population was 43% higher in rural than in urban areas of Algeria in 2015 (see above). This means that rural areas require further attention in terms of their WASH vulnerability. The WVC criterion will have to be developed further to include the rates of waterborne diseases as an important aspect of the vulnerability of the Algerian population. At the time of the preparation of this article, such information was not available in the public domain, to the best of the authors' knowledge.

Use of decentralised wastewater treatment options should be investigated as a potential tool to improve sewage treatment in rural areas of Algeria. These areas, such as the Sahara region of the country, have a high intensity of sunshine. Solar radiation intensity in Algeria varies between 1700 and 2263 h/m^2/year [52,53]. The total annual number of hours of sunshine received by the land surface in Algeria ranges from 2000 to 3900 [53]. This suggests that algal systems for sewage and wastewater treatment could be used to improve treatment across the territory. Such systems should be based on the activity of indigenous algal species adapted to the climatic conditions in a given geographical area.

Table 2 **Source data and the EV and SV values for the total population of Algeria**

Year	***HDI*** **(year$^{0.667}$)**	***GDP*** **(USD/ capita)**	***FUP*** **(dimension less)**	***C_P*** **(dimension less)**	***SV*** **10^3 (year$^{1.5}\times$ USD^{-1})**	***EV*** **(USD×year$^{1.5}$)**	***WVC_T*** **(dimension less)**
1990	0.574	2394.42	0.5209	0.0256	6.87	119.83	0.066
1995	0.596	1444.91	0.5600	0.0189	5.63	156.76	0.063
2000	0.640	1757.01	0.5992	0.0135	3.89	225.60	0.063
2005	0.687	3102.04	0.6383	0.0136	3.63	237.86	0.063
2010	0.725	4473.49	0.6753	0.0178	4.53	191.46	0.065
2011	0.730	5447.40	0.6821	0.0187	4.68	186.48	0.065
2012	0.732	5583.62	0.6887	0.0195	4.89	180.96	0.066
2013	0.734	5491.61	0.6951	0.0197	5.00	179.33	0.066
2014	0.736	5484.07	0.7013	0.0194	4.94	183.61	0.067

By 2015, up to 92.9 % of the Algerian population gained access to cellular/mobile phone technology as active subscribers [54]. The average enrolment in primary education facilities was 97 % for girls and 98 % for boys between 2007 and 2012 [19]. Between 2005 and 2011, around 89-92 % of adults and adolescents aged 15-24 were literate [53].

This is supported further by the fact that only 18 % of all households are headed by a woman, which indicates potentially low levels of disaster vulnerability [55]. WASH vulnerability awareness and mitigation campaigns could be run via SMS, as access to the internet stood only at 18.1 % of the entire population of Algeria, based on reports released in 2016 [54]. Additional information on the disaster risks and vulnerability in terms of health could be collected by the approach of Al Dabbeek [56].

Table 3 **Source data and the *WVC* values for the urban population of Algeria**

Year	***AIWR*$_U$** (%)	***AISR*$_U$** (%)	***WVC*$_U$** (dimensionless)
1990	97.4	91.8	0.024
1991	97.4	91.8	0.024
1992	97.4	91.8	0.024
1993	97.4	91.8	0.024
1994	96.8	91.7	0.026
1995	96.2	91.7	0.027
1996	95.6	91.6	0.029
1997	95.0	91.5	0.030
1998	94.4	91.4	0.032
1999	93.8	91.3	0.034
2000	93.2	91.2	0.035
2001	92.6	91.1	0.037
2002	92.0	91.0	0.039
2003	91.5	90.9	0.040
2004	90.9	90.8	0.042
2005	90.3	90.7	0.043
2006	89.7	90.7	0.045
2007	89.1	90.6	0.046
2008	88.5	90.5	0.048
2009	87.9	90.4	0.050
2010	87.3	90.3	0.052
2011	86.7	90.2	0.053
2012	86.1	90.1	0.055
2013	85.5	90.0	0.057
2014	84.9	89.9	0.058
2015	84.3	89.8	0.060

Table 4 **Source data and the *WVC* values for the rural population of Algeria**

Year	***AIWR*$_R$** (%)	***AISR*$_R$** (%)	***WVC*$_R$** (dimensionless)
1990	85.0	67.7	0.117
1991	85.0	67.7	0.117
1992	85.0	67.7	0.117
1993	85.0	67.7	0.117
1994	84.9	68.4	0.115
1995	84.7	69.0	0.114
1996	84.6	69.7	0.113
1997	84.5	70.4	0.111
1998	84.3	71.0	0.110
1999	84.2	71.7	0.108
2000	84.0	72.3	0.107
2001	83.9	73.0	0.105
2002	83.7	73.6	0.104
2003	83.6	74.3	0.103

Year	$AIWR_R$ (%)	$AISR_R$ (%)	WVC_R (dimensionless)
2004	83.4	75.0	0.101
2005	83.3	75.6	0.100
2006	83.1	76.3	0.099
2007	83.0	76.9	0.097
2008	82.8	77.6	0.096
2009	82.7	78.3	0.094
2010	82.5	78.9	0.093
2011	82.4	79.6	0.092
2012	82.2	80.2	0.090
2013	82.1	80.9	0.089
2014	81.9	81.5	0.088
2015	81.8	82.2	0.086

CONCLUSIONS

A criterion to assess the WASH vulnerability of the Algerian population was defined in this study. Calculation results using open-source data indicate that rural populations in Algeria suffer from higher WASH vulnerability than their urban counterparts. The WVC criterion will have to be developed further to include rates of waterborne diseases as an important aspect of the vulnerability of the Algerian population. At the time of preparation of this article, such information was, to the best of the authors' knowledge, not available in the public domain. Cost recovery from end-users of water must be improved to provide financial sustainability of water management organisations and the water/sanitation infrastructure. The capacity of the water and sanitation sector must be improved to facilitate effective spending of allocated funds, and to speed up project implementation. Decentralised wastewater treatment solutions and awareness campaigns should be implemented in Algeria to address the rising challenges. The use of algal technologies looks particularly appealing. Local governance, i.e. involvement of the widest possible range of stakeholders and disaster management approaches could be used here in the first instance.

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