Journal of Mediterranean Ecology **vol. 19-1, 2021 : 9-16**

Climatic changes impacts on Mediterranean Algeria Tellian Atlas Rivers' flows

Benkhamallah Zahra[1], Lebid Sara[1], Bouguenaya Nadia, Benyahia Mohammed[1], Errih Mohammed[2] and Anani Macho[1]*

[1] *Po. Box 89. Djillali Liabes University of Sidi Bel Abbes. Algeria.*
[2] *Po. Box 1505. University of Es-Senia. Oran. Algeria.*
**Corresponding author email Macho ANANI anani66@yahoo.fr. Tel. 07 95 57 54 37*

Keywords: Climatic changes, Mediterranean Algeria, Semi-arid region, Rivers' flows, Precipitations, Water resources.

Abstract

Recent climatic evolutions induced severe rainfalls decrease Northwestern Algeria southern edge of the Mediterranean Sea resulting in several water droughts most of which have had very negative consequence on local water resources. Unfortunately, the decrease of this essential resource and its unequal distribution were associated with increasing population demand and irrational water management that requires a sustainable water management policy. Water deficit is emphasized by continuing loss of surface and ground water quality mainly due to large population growth, sustained socio-economic development, greedy irrigated agriculture and urbanization. In addition, global warming has been added to the perverse effect of this water stress. Henceforth, the main goal of this study was to determine the direct correlation existing between climatic changes and rivers' flows evolutions and to estimate every situation in this region.

Introduction

Water cycle, land management and environmental sustainability are intimately linked. Sustainable land and water management practices are vital for sustaining agricultural productivity and regional development (Khan and Hanjra, 2008).

Agriculture, industry and drinking water supply are fiercely competing for the access to unfortunately decreasing limited water supplies preventing the development efforts of many developing countries (Remini, 2006).

Intense and persistent drought observed in Algeria and all of North Africa during the last thirty years was characterized by a rainfall deficit estimated at an extent of more than 30% in some cases. This have had a very negative impact on river flow regimes, on the amount of water in reservoirs and on the supply process of underground aquifers with serious consequences for all socio-economic interests of our country (Kettab, 2001).

Even, in the post-apartheid era, South Africa had lived a serious water supply crisis as demand increases from both rural areas and rapidly growing towns and cities. New dams and water transfer systems have been constructed, but they were both controversial and unlikely to fully satisfy demand (Binns et al., 2001)

Regrettably, impacts of climate changes on ecosystems have already been observed and described and recognized also in agro-systems, resulting in an increased vulnerability (Lebid et al., 2015). The climatic conditions threaten to become less favorable for agricultural activity in many regions of the world due to the decrease of rainfalls (Karmaoui et al., 2014).

In the climatic and socio-economic context of the region, water demand is mainly determined by growing demand of potable drinking water, industrial needs and also by the volume of water used through irrigation in the agriculture. These three types of demand competitively exert strong pressure on scarce, time-varying and poorly distributed water resources.

For instance, the tremendous development in central Asia of irrigation since the 1960s combined with unbalanced water resources management led to the destruction of the ecosystems in the delta zone and the gradual desiccation of the Aral Sea, once the fourth largest freshwater lake of the world (Beckchanov et al., 2018).

Northwestern region of Algeria is a typically Mediterranean region with fairly mild and humid winters and dry and very hot summers. It gathers the Oranian and "Chott Chergui" basins characterized by high socio-economic growth and strong competition between drinking water and irrigation demands. Due to recent drought, lack of water has led to significant water transfers from the eastern basins of "Chellif-Zahrez" which receive more precipitations.

Further, the considered area suffers strong climatic variations of great changes. The precipitation regime varies from one region to another and remains characterized by strong annual and seasonal irregularities (Lebid et al., 2012).

This study aims to understand the actual water critical situation. Results and recommendations will help to develop a rational and a sustainable water resource management policy.

Materials and methods

Description of the studied region

Algeria is located North Africa as shown in figure 1. While over 80% of its global surface belongs to the very arid desert climate, less than 20 % remains equally divided between semi-arid plains and sub-humid climates mountainous regions.

Mediterranean climate is prevailing throughout the sea fringe and up to a width of 150 km inland. It is a climate characterized by humid winters, even quite rigorous inwards and summers on the coast but which becomes very hot when one moves inside enough.

Figure 1. Algeria and the Mediterranean Sea.

The studied area is located northwestern Algeria identified as Orania region, just towards southern coast of Spain bathed by the Alboran Sea which communicates directly with north Atlantic Ocean through the strait of Gibraltar.

Mountains of Sierra Nevada, which easily reach 3000 m high in Andalucía, form a veritable barrier that prevents polar flows, originating clouds filled with wetness from the Icelandic depression, to come pouring into our region in autumn and in winter, because prevailing winds are those of the northwest. As a result, the rainfall received rarely exceeds 600 mm and is concentrated mainly around 400 mm at the edge of the definition of a sub-humid zone.

The study area (see fig. 2) is located northwestern Algeria, at the border of the Mediterranean Sea. It is called "Orania" in honor of its capital "Oran" located also at the seaside and is formed by three distinct zones which remain parallel to the coast and divided into the of Tlemcen, Aïn Temouchent, Sidi Bel Abbes, Oran, Mascara, Saïda, Mostaganem and Relizane.

Coastal zone is formed by small plains interspersed with massifs that plunge into the sea and which show magnificent steep cliffs whose feet are dotted with landslides that attenuate the fury of the waves which are particularly violent in autumn and winter. It never extends to a width that exceeds few kilometers.

From the town of Arzew, east of Oran, and as far as the mouth of the Cheliff river eastern, a sandy plain stretches for nearly 80 km, and of which one can see at the bottom the mouth of the Macta river.

From the hydrographic point of view, Algeria has been divided into five (5) hydrographic regions: Orania-Chott Chergui, Cheliff-Zahrez, Algiers-Hodna-Soummam, Constantinois-Seybouse-Mellegue and Sahara, composing 17 watersheds, made up of 261 under watersheds.

The considered region is the western one or Orania-Chott Chergui which is organized in several basins as shown in figure 3.

The superficial flows concern 223 sub-basins of which 191 sub-basins make up the 15 watersheds of the north of the country, 30 sub-basins of the Chott Melghir basin which belongs to the Sahara hydrographic region and 2 sub-basins of the Sahara basin (Sahara southern hydrographic region).

Figure 2. Orania.

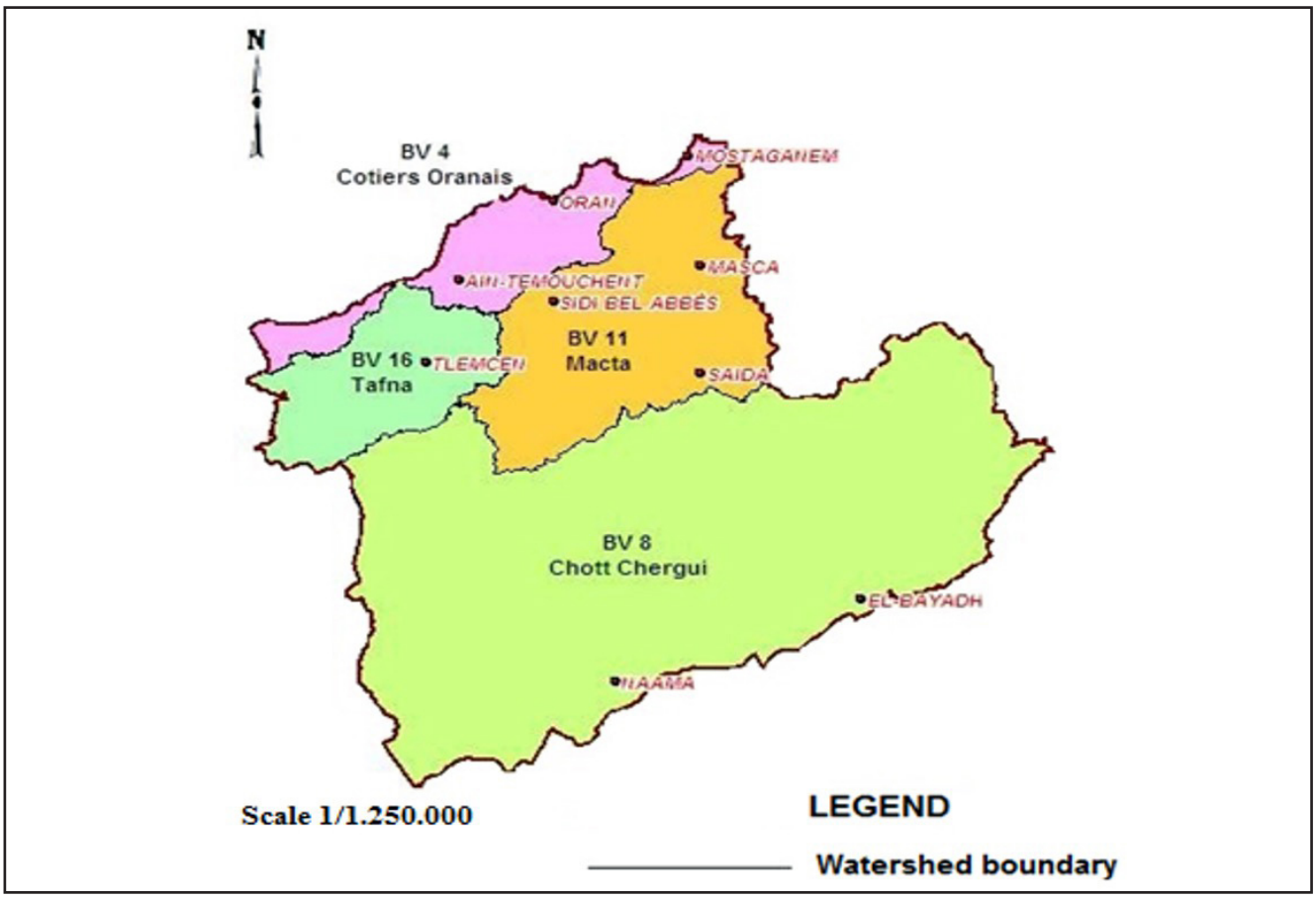

Figure 3. Watersheds in Orania.

The Orania-Chott Chergui region is the largest of the hydrographic regions in Algeria after that of the Sahara region. It includes four watersheds: Tafna, Macta, the Oranian coastal and Chott Chergui (see figure 3).

However, the study area has certain potentialities that should enable it to implement a comprehensive development strategy. Its strategic position make it a dynamical industrial development pole, as well as a region traditionally highly versed in agriculture.

Climate of the province

Climate is relatively almost dry over the whole of this region and oscillates between semi-arid and sub-humid types of weather depending on the years (Lebid et al., 2015).

Annual precipitations are often less than 400 mm excepting heights where it reaches an appreciable extent of 700 to 800 mm.

The majority of rainfalls occurs in winter and in the northern part of the region, and in autumn in the southern part leading sometimes to particular violent floods. The period of drought most often occurs five to six months long, mostly south of the Tellian Atlas chains, and varies from four to six months farther north, especially in the interior plains and Tellian chains.

Rainfalls decrease from east to west and also from north to south direction showing a slight increase to north exposure (Yebdri et al., 2007).

Generally, the climate of the region varies from one basin to another. The westerner Tafna Basins and the Oranian coastlines are characterized by a fresh semi-arid climate with two predominant seasons, which are a wet season extending from October to May with fairly irregular rains and the other dry from June to September with very low rainfall.

Climatic regime is also characterized by winds that usually bring little humidity. The mean annual precipitation on the whole Tafna basin is of 394 mm, with monthly maximum equal to 45 mm in November- December, and to 54 mm in February-March. This monthly average drops to less than only 1 or 2 mm in July-August.

Further east, Macta region, is characterized by a semi-arid climate, when the Chott Chergui basin

in the south is clearly characterized by an arid to semi-arid climate with a relatively cold winter and a warm to hot summer because of its semi-desert and steppe zone characterization.

Nevertheless, this area of about 100,000 km^2 is currently under heavy anthropogenic pressure of around 115 inhabitants per square kilometer even if these latter remain relatively concentrated in the large northern conurbations with a population density of around 185 inh/km^2 or even 315 inh/km^2 in the cities of Oran, Sidi Bel Abbes and Tlemcen. It falls to less than 7 inh/km^2 in the south region of the Chotts (meaning salted lakes).

Interpolating to 2030, according to the services of the Directorate of Planning and Territory Management the population of the districts will be multiplied by 1.5 creating even another enormous pressure on water resources.

Water resources

Currently there are eleven large dams in the study area which are distributed between the Tafna and the Macta rivers, as one can see in figure 4.

Along the Tafna river there are Beni Bahdel, Maffrouch, Sidi Abdeli, Hammam Bougherara and Sikkak dams belonging to the wilaya of Tlemcen in the west (Gagneur, 2006).

In the area of the Macta river there is the dam of Ouizert, Bouhanifia, Fergoug, Sarno, and Cheurfa II. Only the Sarno dam is located in the wilaya of Sidi Bel Abbes while the others are in the wilaya of Mascara in the east. Ain Temouchent is supplied by the Tafna/Dzidiouia plug and a Oued Berkeche dam is planned with a capacity of 5 Hm^3/year (Meddi et al., 2009).

The National Water Plan presents exploitable resources of the Orania-Chott Chergui catchment area of 547 Hm^3/year order for an average year. It is split into 93 hm^3/year for the Oranian Coastal, 74 Hm^3/year for the Tafna basin, 286 Hm^3/year for the Macta basin and 94 Hm^3/year for the Chott Chergui basin (Lambs and Labiod, 2007).

In addition, the assessment of groundwater resources carried out by the National Agency for Water Resources has potentialities of 160 Mm^3/year order in the Oranian region. In addition and in order to equilibrate the repartition of water resources it has been performed a series of frameworks to transfer water from a well supplied region to a depleted one. Great transfer project

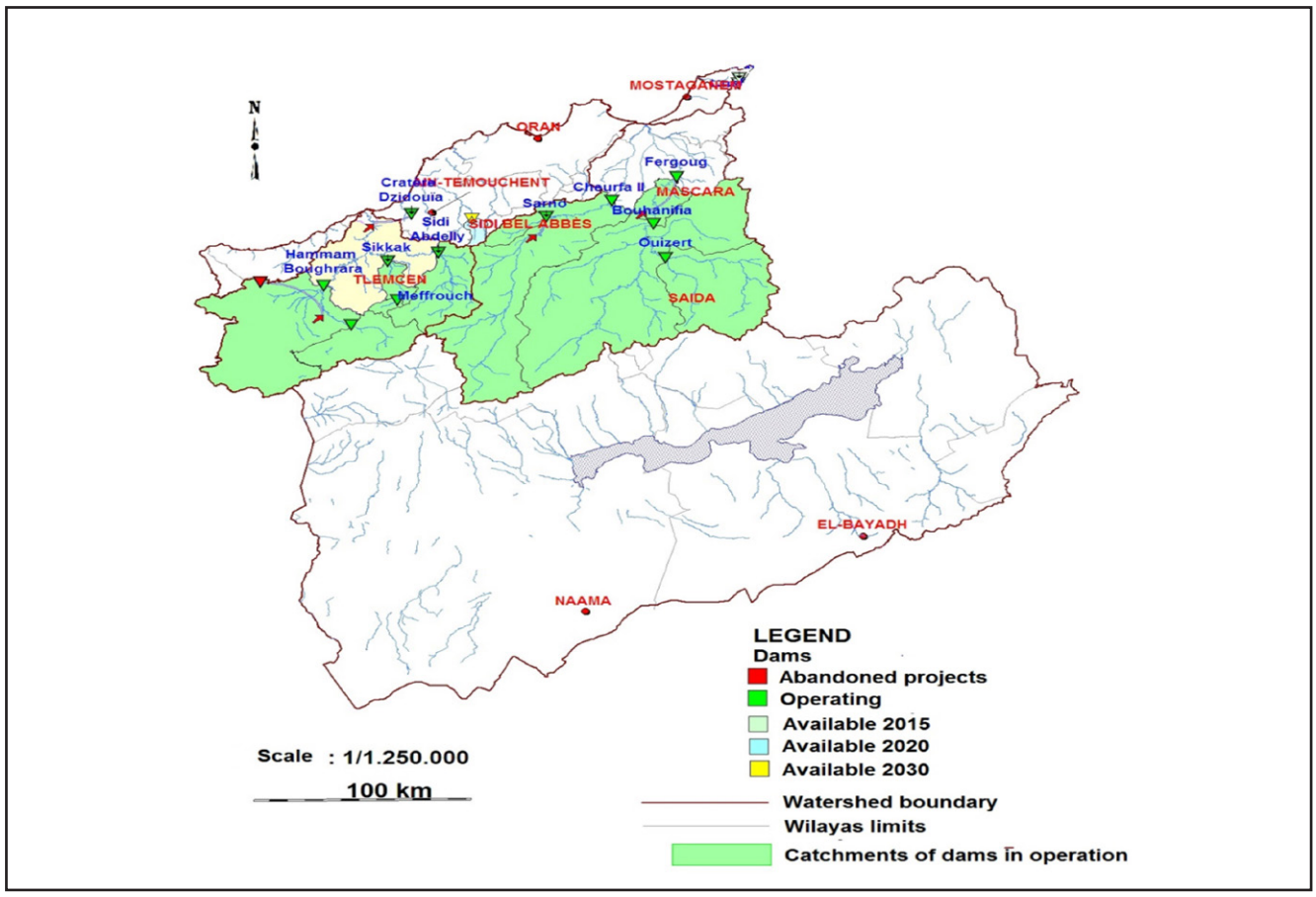

Figure 4. Watersheds and Dams in Orania.

entered in exploitation phase in 2009 after a test stage. It is called MAO for Mostaganem-Arzew-oran Transfer designed to transfer water from the Cheliff basin to the town of Mostaganem for 21 Hm^3 and Oran through arzew for 110 Hm^3 when a deviation supply Mohammadia and Sig for 24 Hm^3. The total transfer is of 155 Hm^3 (Lambs and Labiod, 2007).

Results

Rainfalls constitute the most important factor for hydrological regimes since they constitute in our Mediterranean countries the unique provider of river flows. Precipitations result to water supply have an important influence on the variability of averaged flows at all scales of time. The hygrometric series study conducted on a much long duration permits a correct evaluation of the response of rivers to the variations of climate.

Figure 5 shows the average evolution of rainfall and rivers' flows during a period going from 1980 to 2017.

According to this scheme, one can discern certain characteristics of every Wilaya since one can clearly define two distinctive periods which are:

First, a humid period comprised between September and May alternating wet months and other with lesser precipitations, indicating irregular rainfall regime.

A dry period (June, July, August) is characterized by completely dry months with very few millimeters of rainfall.

In another part, the rainiest months are November with an average of 78 mm, and then January with 71 mm till the month of March. Nevertheless, the most important rainfall degree has been recorded in the district of Tlemcen at the extreme west zone which is also the most elevated one.

Always, according to figure 5, one can see the fact that largest rivers' flows are recorded at the level of the station of Tlemcen too which witnessed the highest rainfall level.

November is always the rainiest month for the four spots, followed also by January, February, March and returning to December.

It is of a pure Winter-Autumn-Spring-Summer shape of climate indicating a very wet winter period preceded by a wet autumn episode and then a dry spring season closed by a very dry summer time.

Figure 5 shows the fact that precipitation curves are similar, which seems to indicate the fact that they are related to same and single region and they face so the same weather conditions and same meteors.

However, the amount of water received differs from one area to the other. The region of Tlemcen is the wettest due to its' mountain orography that intercept clouds and its rivers' flows are the most important.

However having reached their maximum output in the month of March there is a strong decline due as well either to the natural flow and to the restrains in the dams of the Wilaya of Tlemcen. These will later go to feed neighboring eastern Sidi Bel Abbes and Ain Temouchent Wilayas.

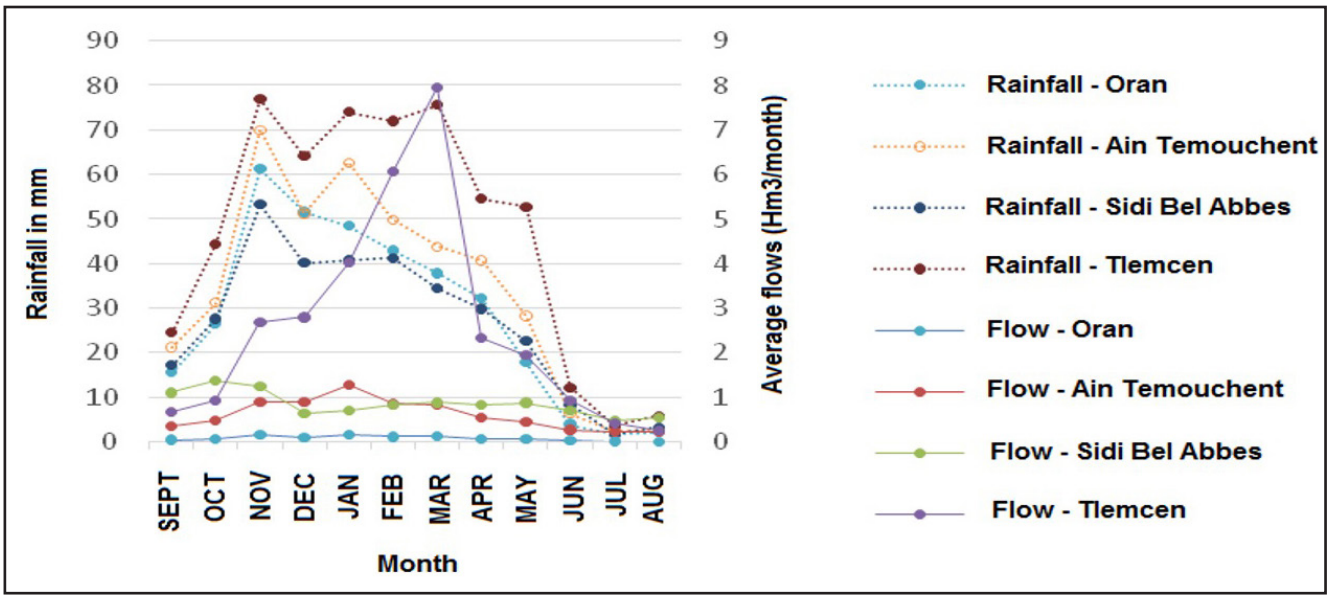

Figure 5. Rainfalls and average flows in the region (1980 – 2017).

The area of Sidi Bel Abbes, although spreading in an average area plain, receives also a fairly significant amount of precipitation but less than that of coastal Ain Temouchent and receives first most of the wetness.

However, the abundance of flowing water of the rivers is originated by the mountains of Dhaya more South and then arrive in the plain of Sidi Bel Abbes, where the flows are strong of September and October in the beginning of the wet season.

On the other hand, these flows are not commensurate with those in the area of Tlemcen which are almost four times higher practically all year round.

The area of Oran spanning in a poorly watered coastal region because unfortunately undergoing the barrier effect of the Sierra Nevada in Spain at the North, it is obvious that the two outflow regimes of these rivers are fairly low throughout the year, it is for this reason that was made a station of desalination of sea water at Mers el Hadjadj city in the East of the area and a large water transfer called the MAO has operated from the eastern Cheliff river.

Then, one can finally distinguish two groups of two outflow regimes of rivers following responses to precipitations:

1. Both Sidi Bel Abbes and Ain Temouchent stations are characterized by quite instant hydrological response to precipitations.

2. Oran spot is characterized by a rather slow or even non-existent hydrological response during the same period. This can be explained either by the geography of the stations as previously mentioned due to natural barriers formed by mountain ranges that reduce penetration of the clouds that generate precipitation, or by rainfall greatly reduced in the study area.

The relationship between the monthly average flow rates and the monthly average rainfall also represented on figure 5 shows therefore a close and intimate correlation or an obvious synchronism between precipitation and outflow rates, this almost in real time. Indeed, when the precipitations increase rivers' flows increase proportionately and at the same time.

Automatically the volume of both surface and underground water also increases while periods of recession appear when rain fade or completely stop.

Conclusion

Even if Algeria is under a very stressing pressure of global precipitations depletion, it tries to use an adequate strategy in order to overcome this unfortunate situation. Climatic change with decreasing rainfall and slight augmentation of average temperature has caused a lot of problems to this region.

Nevertheless, this study has demonstrated a strong correlation between rainfall and rivers' flows. This particular relation can led to a concrete policy of a better management of rivers' flow, since one have to build particular dams or hillside restraints elaborating a policy of water conservation in a first step and then establish a policy of water taking care, and in parallel a water recycling policy finishing by a sustainable policy of water management.

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